OAR Box 1214

Prepped by Ollie Stewart

Document Number:

66) IV-D-32

Docket Number:

A-91-46

A-91-46

IV-D-32

ETHYL CORPORATION

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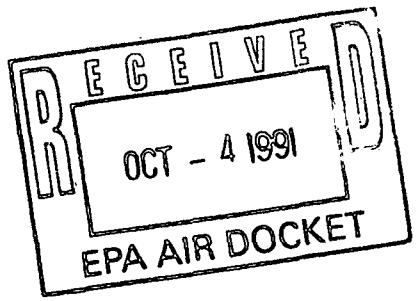
Lt. Gen. Jeffrey G. Smith, U.S.A. (Ret.)
Director of Government Relations

4 October 1991



Mr. William K. Reilly
Administrator
The United States Environmental Protection Agency
401 M Street, SW
Washington, D.C. 20460

Re: Ethyl HiTEC® 3000, Docket A-91-46

Dear Mr. Reilly:

Transmitted herewith are comments in support of Ethyl Corporation's July 12, 1991 waiver request to use its fuel additive HiTEC® 3000. The comments address issues raised either during the September 12, 1991 public hearing on that request or comments received to date in the docket.

Ethyl anticipates commenting further, where appropriate, on any waiver-related comments, not presently in the docket, which are received by the EPA.

Sincerely,

Jeffrey G. Smith

Enclosure

cc: Ms. Mary T. Smith
Director, Field Operations and Support Division (EN-397 F)
U.S. Environmental Protection Agency

BEFORE THE
UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

IN RE APPLICATION FOR A FUEL ADDITIVE WAIVER FILED BY ETHYL CORPORATION UNDER § 211(f)(4) OF THE CLEAN AIR ACT

ETHYL CORPORATION'S COMMENTS IN SUPPORT OF THE HiTEC® 3000 WAIVER APPLICATION

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October 4, 1991

Executive Summary

I. INTRODUCTION

Ethyl Corporation manufactures an automobile performance additive under the trademark HiTEC 3000 performance additive. It is a manganese-based octane improver that is used in leaded gasoline in the United States and in unleaded gasoline in Canada. On July 12, 1991, Ethyl Corporation filed a waiver application with the U.S. Environmental Protection Agency ("EPA") under provisions of the Clean Air Act.

Ethyl is seeking permission to use HiTEC 3000 performance additive at a concentration of 1/32 gram of manganese per gallon in unleaded gasoline in the United States.

In cooperation with the EPA, Ethyl conducted four years of testing on a 48-car fleet operated for a total of more than three million miles. The comprehensive Ethyl research program is the most extensive ever undertaken in support of a fuel additive. Thousands of emission measurements were generated and analyzed. The data show that use of HiTEC 3000 performance additive ("the Additive") will reduce total regulated emissions from vehicles by about eight percent, on average. Also, all current emission standards will be met by vehicles operated on fuel with the Additive.

II. PUBLIC HEARING

On September 12, 1991, the EPA held a public hearing on Ethyl's waiver application. Only one organization, the Motor Vehicle Manufacturers Association (MVMA), testified in opposition to the additive. MVMA did not directly dispute the results of Ethyl's rigorous testing program. Instead, MVMA offered the results of limited emissions tests conducted by Ford Motor Company ("Ford").

The tests conducted by Ford were narrow in design and flawed in concept. They, therefore, present no challenge to the conclusions drawn from Ethyl's extensive testing program, which was developed in consultation with the automobile manufacturers and the EPA. Furthermore, the data generated by Ford actually support the conclusion that all applicable emission standards will be met by vehicles operated on fuel with the Additive. Finally, questions raised by the MVMA in its testimony were already answered in earlier materials submitted by Ethyl in its waiver application.

The following is a more detailed discussion of these three points.

III. THE FORD TEST PROGRAM IS FLAWED

The flaws in the Ford test program and the reasons why EPA should not give them weight in considering the waiver application are numerous.

- The Ford "fleet" did not represent the national fleet. Ethyl tested 48 cars -- six cars from each of eight different model types -- representing more than 50 percent of the vehicles sold in the U.S. during the

applicable model year. Ford tested only eight cars -- four cars from each of two model types -- including one prototype model not representative of any production vehicle. A true picture of emissions is not available from the Ford data.

- Ford did not obtain data to examine trends. More than 2,100 emission measurements values were taken under Ethyl's testing; each of the 48 cars was checked at 5,000-mile intervals. Only about 120 such emission values were generated by Ford's testing of its eight vehicles spread out over 20,000- or 25,000-mile intervals. A definitive analysis of emission trends is not possible from Ford's data.

- Ford did not use independent laboratories. To insure the integrity of the data and analysis, Ethyl relied on independent laboratories and analysts. Ford did not -- instead the Company used in-house facilities and personnel. Ford's longstanding and outspoken opposition to the Additive is well-documented.

- Ford did not control variables among vehicles. The results Ford obtained in its testing clearly indicate that use of the Additive was not the critical variable affecting emissions. For instance, even vehicles run on clear fuel show a wide variance in HC emissions -- more than a factor of two -- at the 55,000-mile point.

- Ford's data is not credible. Ford's attempt to generalize the effect of the Additive on emissions from the national car fleet based on its limited data is inappropriate because Ford's overall test results generally reflect the emission performance of a single test vehicle, and in some cases a single mileage interval.

IV. FORD TESTS SUPPORT USE OF THE ADDITIVE

The basic test to be met for the approval of a waiver application is whether an additive "causes or contributes" to the failure of emission control systems to meet applicable emission standards. Ford offered no evidence to counter Ethyl's extensive proof that the Additive does not cause or contribute to the failure of such systems.

Even if the Ford test data is accepted at face value, it demonstrates that all current emission standards will be met by vehicles using fuel with the Additive. The data submitted by Ford show only a single failure to meet the HC standards -- a statistically insignificant effect. In all other instances, current HC, CO and NO_x emission standards were met by all of Ford's test vehicles using fuel with the Additive.

V. MVMA'S QUESTIONS LACK MERIT

In its comments, MVMA expressed several questions which Ethyl has already addressed in its voluminous waiver application. A brief recitation of some of the answers follows.

- Detergents -- MVMA questioned why Ethyl ran its test using a clear fuel without detergents; Ford used fuel with detergents. The reason for Ethyl's choice of test fuel is obvious. The tests were designed to isolate the effect of the Additive. Using detergents introduces an unnecessary variable. Also, a stated MVMA concern is the creation of deposits, but using detergents would hide evidence of deposits. Finally, Ethyl and others have run tests using the Additive in detergent fuels; the resulting data has always been consistent with that produced in Ethyl's 48-car test program.

- Driving Cycle -- MVMA questioned the driving cycle used in the Ethyl testing program. The mileage accumulation driving cycle used is that required by the EPA for the certification of vehicles under its regulations.

- Emission Tests -- MVMA suggests that the Ford program is more statistically sound since Ford took six emission measurements at three or four mileage intervals, while Ethyl took a minimum of two emission measurements at 15 mileage intervals. In fact, the Ethyl data is far more statistically significant because the issue in this proceeding is not the repeatability of the emission measurement tests, but rather, emission trends over time for the national car fleet. The control of vehicle-to-vehicle or model-to-model variability, as reflected in the 48-car test

program, is far more important than control of the variability in specific emission measurements.

- Mileage Accumulation -- MVMA questioned why Ethyl tested emissions up to 75,000 miles when Ford tested up to 100,000 miles. In fact, the test vehicles are certified only up to 50,000 miles, and Ethyl's tests exceeded that requirement by 25,000 miles. Ethyl established clear emissions trends, and confirmed this with additional 100,000 mile tests on four Chevrolet Corsicas.

- Catalytic Converters -- MVMA questioned if data from Ethyl's testing of catalytic converters indicated a significant increase in backpressure. In fact, the Ethyl tests showed no adverse effect, and MVMA's speculation is based on a specious extrapolation. Furthermore, General Motors said at the hearing that its tests show no such effect.

- Manganese/Public Health -- MVMA questioned the public health effect of the Additive based on a single airborne manganese measurement obtained by Ethyl. The air sample -- of an 8-hour period of heavy traffic in a parking garage -- was designed to produce an extreme worst-case measurement. Can anyone reasonably assume that there is any individual who will spend 24 hours a day, for a lifetime, in a parking garage with heavy traffic? All other evidence from Canadian and other tests shows no health risk associated with manganese emissions.

VI. CONCLUSION

Ethyl has performed the most extensive testing program ever conducted on a fuel additive, and after more than a year and a half, the fundamental data still stand unchallenged. The conclusion stands as well: All applicable emission standards will be met with the use of HiTEC 3000 performance additive.

The agency should promptly approve this waiver application.

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APPENDICES

I. INTRODUCTION

On July 12, 1991, Ethyl Corporation ("Ethyl") filed a fuel additive waiver application under § 211(f)(4) of the Clean Air Act ("CAA" or "Act") for use of the HiTEC® 3000 performance additive ("the Additive") at a concentration not to exceed 0.03125 gram (1/32nd) manganese per gallon as the Additive in unleaded gasoline. On September 12, 1991, the U.S. Environmental Protection Agency ("EPA" or "Agency") held a public hearing on Ethyl's waiver application at which the Agency heard testimony from five interested organizations and individuals. Four of those testifying favored approval of Ethyl's waiver application. Only one organization, the Motor Vehicle Manufacturers Association ("MVMA"), testified in opposition to Ethyl's waiver application, suggesting that limited emission tests run by Ford Motor Company ("Ford") were inconsistent with the extensive data generated by the 48-car test fleet on which the waiver application is based. The purpose of these comments is to respond to the MVMA testimony. In view of the nature of the questions and assertions presented by MVMA on the Ford testing, Ethyl intends to file additional comments evaluating the Ford program as soon as adequate information is made available by Ford.

II. THE EMISSION TESTING CONDUCTED BY FORD MOTOR COMPANY

In earlier submissions to the docket, Ethyl described the results of a core test program designed in consultation with the three major U.S. automobile manufacturers (including Ford) and

staff at EPA.[1/] As noted, this test program generated thousands of emission measurements from 48 cars operated for a total of more than 3 million miles.

Data from the Ethyl test program showed that use of the Additive over the course of 75,000 miles of vehicle operation reduced nitrogen oxide ("NOx") emissions, on average, by 20 percent (or 0.11 gram per mile).[2/] Carbon monoxide ("CO") emissions were reduced, on average, by seven percent (or 0.22 gpm). While hydrocarbon ("HC") emissions increased slightly for the vehicles using the Additive, total regulated emissions from vehicles operating on fuel containing the Additive were lower, on average, than clear fuel vehicles by about eight percent (or 0.30 gpm).

Independent analysts subjected these data to a rigorous statistical evaluation to determine if use of the Additive caused

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[1/] Ethyl initiated discussions with EPA and the automobile industry in late 1987 to design a comprehensive test program addressing the effects of the Additive on automobiles and emission control systems. All aspects of the fuel additive test program were addressed, including the types and numbers of vehicles to be tested, and the type of fuel to be used in the test vehicles. See Reply Comments of Ethyl Corporation in Support of the HiTEC® 3000 Waiver Application (August 10, 1990) (hereinafter "Ethyl Reply Comments"), Appendix 1 ("Ethyl Memoranda Concerning Meetings with EPA and the Automobile Companies on the Design of the Test Protocol") (Two letters dated July 19, 1988 and July 22, 1988 summarize the discussions that took place over eight months between Ethyl and EPA regarding design of the test program. Three Ethyl memoranda of February 11, 1988 summarize discussions with General Motor Company, Ford Motor Company, and Chrysler on the composition of the test fleet and the expressed concerns of the automobile companies.).

[2/] "Gram per mile" will hereafter be designated "gpm."

or contributed to the failure of emission control devices or systems to meet applicable emission standards, as required under the terms of § 211(f)(4). Analysis of these data using both statistical methods long applied by the Agency in evaluating waiver applications and other statistical tests showed that use of the Additive would not cause or contribute to the failure of emission control devices to meet applicable standards, including the HC emission standard.[3/]

Without directly disputing these findings based on Ethyl's testing, MVMA described the results of a limited emission test program recently completed by Ford on a set of eight vehicles using fuel with and without the Additive. Ethyl's efforts to evaluate the Ford test data have been hampered by the absence of raw test data (which was only received on September 24) and a detailed description of the Ford test protocol (including a description of the other testing conducted by Ford on the test

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[3/] The MVMA asserts in its testimony that the relevant standard under § 211(f)(4) is whether use of the Additive "impair[s] to a significant degree the performance of any emission control device or system." See MVMA September 12, 1991 Statement Regarding Ethyl Corporation's Application for Fuel Additive Waiver Dated July 12, 1991 (hereafter "MVMA Testimony") at 3. The relevant question under § 211(f)(4) is not whether use of a new fuel or fuel additive "impairs" the performance of emission control devices or systems, but rather whether the new fuel or fuel additive " will . . . cause or contribute to a failure" of emission control devices or systems to meet applicable emission standards. 42 U.S.C. § 7545(f)(4)(emphasis added). No such cause or contribute effect can be attributed to use of the Additive based on either the Ethyl or Ford test data. See infra at 19-22.

vehicles concurrent with testing of the Additive).[4/] A letter has been sent to Ford requesting the information necessary to evaluate fully the Ford test program.[5/]

A review of the limited information that has been made available by Ford, however, indicates that the Ford program was too narrow in scope and design to detract from the substantial data that have been offered in support of the waiver application by Ethyl and other parties. Moreover, this review suggests that Ford's results are in no way inconsistent with the fundamental finding from Ethyl's 48-car test program -- i.e., use of the Additive will not cause or contribute to the failure of emission control devices to meet applicable emission standards.

A. The Ford Test Program Has Significant Shortcomings Which Limit Its Usefulness in the Waiver Proceeding.

MVMA asserted at the hearing that the results of the Ford test program were very different from the results of the 48-car

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[4/] Ethyl received the raw test data for the Ford test program on September 24, 1991, about a week and one-half before these comments were due. By contrast, Ford has had the data from Ethyl's 48-car test fleet for well over one year. Other information vital to an evaluation of the Ford test data which has not been provided by Ford includes (1) data on the maintenance of the test vehicles, and (2) information on the drivers used for emission testing and how they were assigned to the test vehicles.

[5/] See Letter to David L. Kulp from Donald R. Lynam dated October 2, 1991. A copy of this letter is Appendix 1 to these comments. Given the absence of adequate time to evaluate the Ford test program prior to October 4, 1991, Ethyl intends to file additional comments fully evaluating the Ford program as soon as adequate data are made available. In addition, Ethyl will continue after October 4, 1991 to respond, as appropriate, to the comments of others who raise questions or concerns about the Additive.

fleet test program. MVMA claimed, for example, that "MMT caused a two- to three-fold increase in HC emission levels," and an increase in NOx emissions, but had "little effect . . . on CO emissions."[6/] These bold assertions are based on extremely limited data obtained from a handful of vehicles.

A direct comparison of the Ford and Ethyl test protocols indicates that the Ethyl test program was far more extensive and rigorous than the Ford program, both in terms of the number and kinds of vehicles tested and the number of emission measurements generated for each test vehicle. The Ethyl test program better reflects by far the effect of the Additive on emissions for the national automotive fleet.

For these reasons, little weight should be given to the Ford allegations.

1. Ford has not tested vehicles representative of the national car fleet.

In interpreting § 211(f)(4), EPA has recognized that an applicant need not demonstrate that every vehicle, when using fuel containing the additive for which a waiver is sought, will meet emission standards. EPA has stated that such a burden would be "virtually impossible to meet as it requires the proof of a negative proposition, i.e., that no vehicle will fail to meet the emission standards with respect to which it has been certified.

6/ MVMA Testimony at 2.

Taken literally, it would require the testing of every vehicle."[7/] Acknowledging that Congress intended to create a workable waiver provision, EPA has interpreted § 211(f)(4) to require the use of "statistical sampling" and "fleet testing protocols" to draw meaningful conclusions regarding the effect of an additive.

Furthermore, EPA's waiver application guidance makes clear that any such statistical sampling must be conducted on a fleet of vehicles representative of the "national automobile fleet."[8/] To meet these criteria, Ethyl, in consultation with EPA and the auto industry, designed a test fleet that included six cars from each of eight different vehicle types representing over 50 percent of the vehicles sold in the U.S. during 1987.[9/] Ethyl tested four vehicle models manufactured by General Motors (the 2.0 liter Cavalier, the 2.5 liter Buick, the 2.8 liter Buick, and the 3.8 liter Buick), three vehicle models manufactured by Ford

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[7/] See, e.g., Conditional Grant of Application for a Fuel Additive Waiver Submitted by E.I. DuPont de Nemours and Company, Inc., EN-84-06 (January 10, 1985) at 6; Grant of Application for a Fuel Waiver Submitted by the Synco 76 Fuel Corporation (Synco), EN-81-20 (May 18, 1982) at 4-5; Grant of Application for a Fuel Waiver Submitted by the Atlantic Richfield Company, EN-81-10 (November 7, 1981) at 3-4; 45 Fed. Reg. at 58955 (September 5, 1980); In Re Application for Arconol, MSED-ZU(f)(4)-TBA (February 6, 1979) at 4; 44 Fed. Reg. at 37075 (June 25, 1979); 44 Fed. Reg. at 12243 (March 6, 1979).

[8/] 43 Fed. Reg. 11258 (March 17, 1978).

[9/] See In Re Application for a Fuel Additive Waiver Application Filed by Ethyl Corporation under § 211(f)(4) of the Clean Air Act (May 9, 1990) (hereinafter "1990 Waiver Application"), Appendix 1 ("Fleet Test Protocol"), Attachment 1-1.

(the 1.9 liter Escort, the 3.0 liter Taurus, and the 5.0 liter Crown Victoria) and one model manufactured by Chrysler (3.0 liter Dodge Dynasty).

Ford, by contrast, tested only two vehicle models (both produced by Ford) which account for a only about three percent of the vehicles currently sold in the U.S.[10/] Indeed, four of the eight Ford test vehicles were "prototypes," unrepresentative of any existing production vehicles.[11/] The other four vehicles were, in the words of the Ford representative, "somewhat of a worst case," not "typical of an average car in the U.S."[12/] By its own admission, therefore, the Ford test "fleet" cannot be deemed to meet the "representativeness" criteria which Ford itself has expressly acknowledged applies.[13/]

10/ See Automotive News 1990 Market Data Book; compare1990 Waiver Application, Appendix 1 ("Fleet Test Protocol"), Attachment 1-1.

11/ See, R.G. Hurley, et al., "The Effect on Emissions and Emission Component Durability by the Fuel Additive Methylcyclopentadienyl Manganese Tricarbonyl (MMT)," Docket No. IV-D-01, at 3.

12/ Public Hearing Transcript In Re: Ethyl Corporation Fuel Waiver Application (September 12, 1991) (hereafter "Transcript") at 24.

13/ See Ford Motor Company's Reply Comments to Ethyl Corporation's August 10, 1990 Submission to EPA Regarding their Application for a Waiver to Allow the Addition of MMT to Unleaded Gasoline (October 29, 1990) (hereafter "Ford Reply Comments"), Docket No. IV-D-203, at 12 ("We agree with Ethyl's argument that they must only prove emission effects on the overall car fleet.")(Emphasis added).

2. Ford did not conduct enough testing to accurately gauge trends in vehicle emissions.

As part of Ethyl's 48-car test program, independent laboratories tested emissions from each of the 48 cars at 5000 mile intervals extended over 75,000 miles of vehicle operation. There are therefore 15 separate emission measurement intervals for each of the three regulated pollutants for each test vehicle over the course of the Ethyl test program (excluding the 1000 mile "start-of-test" measurement point). By contrast, Ford measured emissions for each of its eight test vehicles at only three or four intervals over the course of 100,000 miles of operation, depending upon the test vehicle.

In contrast to the Ford program, therefore, Ethyl designed the 48-car test program to present sufficient data to evaluate with confidence trends in vehicle emissions. These trends can be seen in the more than 2100 emission measurement values generated as a part of Ethyl's test program. Ford, by contrast, generated only about 120 such emission values. The effect of this fundamental difference in the Ford and Ethyl test programs can be illustrated conceptually using a simple example.

Suppose the EPA hearing panel desired to determine the average weight of all of the persons present at the public hearing and asked Ford and Ethyl to provide estimates of the average weight. For purposes of this example assume that 100 persons attended the public hearing. Analogizing to the Ford test program, Ford would have repeatedly measured the weight of only eight individuals for a total of six weight measurements for

each of the eight individuals. Ford would then have averaged the six measurements for each individual, and averaged the "average" weights of the eight individuals together to obtain an estimate of the average weight of the 100 persons attending the hearing.

Ethyl, by contrast, would have measured the weight of 48 individuals at least twice for each individual, and then averaged the "averages" for these 48 individuals to obtain the desired weight estimate. Ethyl concedes that under the Ford approach, Ford would obtain a slightly better estimate of the weight of each of the eight individuals weighed by Ford. Ford would not, however, obtain a better estimate of the average weight of the 100 persons attending the public hearing. There is little variability in the weighing process. The major variability in weights occurs between persons. Ethyl's approach would be better suited for estimating average weight since, by definition, a much larger sample of weights would be obtained upon which to base an estimate of average weight.

The same conclusions apply when comparing the Ford and Ethyl emissions test programs. All other variables aside, confidence in the accuracy of the emission measurements for each vehicle in the Ford test program at any particular mileage interval may be slightly higher than the corresponding confidence for emission measurements at the intervals in the Ethyl test program.[14/]

[14/] As a practical matter, however, confidence in the Ethyl test data is higher than that for the Ford data given that the independent laboratories retained by Ethyl to conduct emission testing correlated emissions among themselves, and with the EPA

(continued...)

Ethyl's use, however, of a more diverse and far larger sample of test vehicles, as well as the much larger number of sampling intervals, provides much higher confidence that the 48-car test results are representative of emission effects for the national car fleet.

For this reason, MVMA's assertion that Ford's test design results in "increased statistically significant overall data" because of their six tests per interval is curious and simply misinformed. As explained by statistical experts from System Applications International ("SAI"):

> Statisticians, when designing experimental test programs, have to consider all sources of uncertainty and how they will affect the outcome of interest. In the case of emissions testing from light-duty vehicles, test-to-test variability is the smallest source of variability. Car-to-car variability is much, much larger (orders of magnitude). The gain, in a statistical sense, going from two or three tests per interval to six tests per interval is extremely small. A far better experimental design for Ford would have been to double the number of vehicles and halve the number of tests per interval.[15/]

[14/] (...continued)
Ann Arbor test laboratory on a subset of the Ethyl test vehicles. See In Re Application for a Fuel Additive Waiver Filed by Ethyl Corporation under § 211(f)(4) of the Clean Air Act (July 12, 1991)(hereafter "1991 Waiver Application"), Appendix 3 ("Laboratory Correlation Program"). No similar information regarding Ford's ability to correlate emissions from the Ford test vehicles with these independent laboratories or EPA's Ann Arbor laboratory has been provided by Ford.

[15/] See Memorandum from Alison Pollack and Jonathan Cohen, Systems Applications International to Ethyl Corporation dated October 2, 1991. A copy of this memorandum is Appendix 2 to these comments.

3. Ford's test program, unlike the Ethyl test program, was not conducted by independent laboratories.

As a part of the 48-car test program, two independent laboratories (Automotive Testing Laboratories, Inc. in South Bend, Indiana and ECS Laboratories in Livonia, Michigan) conducted all emission testing on Ethyl's behalf. Two other independent consultants (SAI and Roberson Pitts, Inc.) conducted the primary statistical analyses of the test data. Moreover, the independent laboratories involved in this test program also participated in an emissions correlation program with EPA's Ann Arbor test laboratory.[16/] Confidence in the integrity of the 48-car test data is therefore high. A similar degree of confidence in the independence and objectivity of the Ford data is lacking because Ford conducted all testing and analyses "in-house," notwithstanding Ford's longstanding concerns about the Additive.[17/]

[16/] See 1991 Waiver Application, Appendix 3 ("Laboratory Correlation Program").

[17/] Others have independently questioned the credibility of auto industry testing. See, e.g., Critical Analysis of the Federal Motor Vehicle Control Program, Northeast States for Coordinated Air Use Management ("NESCAUM") (July 1988) at p. 25 ("The certification process ... must as a practical matter deal with prototype cars (sometimes almost handmade) in an artificial environment (very careful maintenance, perfect driving conditions, with well-trained drivers using ideal roads or dynamometers, etc.). As a result, one can say with confidence that cars that fail to meet emission standards during certification would have certainly also failed to meet standards in use; however, the converse is not true, i.e., one cannot say with confidence that cars that pass certification will inevitably perform well in use."). Ethyl, by contrast, used commercially

(continued...)

4. The Ford test program did not adequately account for potential vehicle-to-vehicle emission variability.

The limited number of vehicles tested by Ford precludes any definite conclusions about the Additive's effect on vehicle emissions. For example, most of the apparent increase in HC emissions attributed by Ford to use of the Additive occurred in the "prototype" Ford Explorers.[18/] The prototype Explorers, however, exhibit a wide variability in vehicle-to-vehicle emissions.

As noted by Ethyl at the public hearing, HC emissions for the two clear fuel Explorers vary by more than a factor of two at the 55,000 mile measurement point: 0.154 gpm for vehicle 305 and 0.353 gpm for vehicle 307.[19/] Upon further examination, this wide variation in clear fuel vehicle emissions appears to apply consistently at all mileage intervals, since overall average HC emissions for vehicle 307 are approximately twice as high as those for vehicle 305.[20/] Similar variability in emissions

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17/ (...continued)
available vehicles for its test program. 1990 Waiver Application, Appendix 1 ("Fleet Test Protocol").

18/ See Letter to Mary Smith from David Kulp dated September 23, 1991, Docket No. IV-D-10.

19/ See R.H. Hammerle, et al., "Particulate Emissions From Current Model Vehicles Using Gasoline with Methylcyclopentadienyl Manganese Tricarbonyl," (hereinafter "Ford Particulate Analysis"), Docket No. IV-D-01, at 3, Table II.

20/ See Memorandum from Ralph Roberson, Systems Applications International, to Ethyl Corporation dated October 3, 1991. A copy of this memorandum is Appendix 3 to these comments.

occurs for the Additive-fueled Explorers. At 55,000 miles, for example, the emissions are 0.548 gpm for vehicle 304 but only 0.173 gpm for vehicle 306.[21/]

Given this variability in vehicle-to-vehicle emissions, the data clearly indicate that use of the Additive is not the critical variable affecting emissions in Ford's test program. In fact, the wide variability observed in vehicle-to-vehicle emissions suggests that other variables could play a more important role in ultimate emissions than use of the Additive. For this reason, the mere fact that differences in emissions between the clear and Additive-fueled vehicles in Ford's test program may be statistically significant does not mean that this difference can be attributed in part or in full to the Additive.[22/]

[21/] Ford Particulate Analysis, Table II.

[22/] There are many anecdotal examples of statistically significant correlations that fail to explain reality. One such study, for example, established a statistically significant relationship between shoe size and IQ. Another showed a correlation between the number of births in the U.S. and the number of storks in England. The lesson to be drawn from these studies is that "statistical significance" as a concept has real value only to the extent that one is confident that potentially confounding variables in a test protocol have been adequately controlled. The Ford test design did not provide such control and, therefore, one must be cautious not to read too much into the Ford test data.

5. Preliminary analysis of the Ford test data shows that it lacks credibility.

a. The Ford Explorers

The emission data from the Ford test program are highly erratic. Plots of the Ford data show, for example, that one of the Additive-fueled Ford Explorers (car 306) performed adequately up to 55,000 miles.[23/] Up to that point, its emissions were even better than one of the clear fuel Ford Explorer vehicles (car 307). At the 55,000 mile interval, however, Ford discovered spark plug and fuel injector problems in vehicle 306, and these problems were serious enough to require the replacement of these components.[24/]

Notwithstanding these unscheduled component changes, Ford failed to take additional emission measurements from vehicle 306 until 50,000 miles later, at which time Ford discovered yet an additional component failure. Given these component failures and the absence of any emission data between 55,000 and 105,000 miles for vehicle 306, there is no credible way to determine with any confidence the source of the emission deterioration in vehicle 306. Indeed, these data suggest that, if anything, equipment deterioration and maintenance problems have a far larger effect on exhaust emissions than use of the Additive.

[23/] See Appendix 3, Figure 2.

[24/] See Letter to Mary T. Smith from David L. Kulp dated September 23, 1991, Docket No. IV-D-10.

By comparison, apparently no unscheduled maintenance was required in the clear fuel Ford Explorers. Indeed, the data show a phenomenal (almost unbelievable) HC emission performance for clear fuel vehicle 305. It experienced essentially no deterioration in HC emissions over the course of 100,000 miles.[25/] Against this backdrop, even the performance of clear fuel vehicle 307 looks poor.[26/]

Finally, the one remaining Additive-fueled Ford Explorer (vehicle 304) had the highest initial HC emission measurements of any Explorer -- almost twice as high as the initial measurements for clear fuel vehicle 305.[27/] Given this variability in the initial emission levels, the performance of vehicle 304 provided from the very start of the test a questionable basis for drawing sweeping conclusions about the effect of the Additive on emissions. In this regard, the sharp drop in HC emissions (approximately 0.2 gpm) from the 85,000 to the 105,000 mile intervals is especially curious, and directly undercuts Ford's suggestion that deterioration increases with increased mileage.

MVMA also suggests that Ford's test program shows increased NOx emissions associated with use of the Additive. As with other conclusions drawn from the data by Ford and MVMA, this conclusion is driven by the emission results for the "prototype" Ford

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25/ Appendix 3, Figure 2.

26/ Id.

27/ Id., Figure 4.

Explorers. While average NOx emissions for the clear vehicles in Ford's test fleet are lower overall (0.265 gpm vs. 0.273 gpm), this difference is not consistent from model to model. In fact, the NOx emissions from the Additive-fueled Ford Escorts are, on average, lower than their clear fuel counterparts (0.37 gpm vs. 0.38 gpm), a result which is fully consistent with Ethyl's test results.

The difference in overall average NOx emissions in the Ford test program is largely attributable to the NOx emissions from one of the Ford Explorers, vehicle 304. Of note, however, this vehicle also had the lowest deterioration in NOx emissions of all of the vehicles in the Ford test fleet over the course of the Ford test program.[28/] This anomaly further illustrates the difficulty in interpreting the Ford test results.

Ford's attempt, therefore, to generalize the effect of the Additive on emissions from the national car fleet based on its limited test data is inappropriate. Ford's overall test results can generally be explained by the emission performance of a single test vehicle, and in some cases at a single mileage interval, and thus provide no meaningful information on national car fleet effects. Given the far larger number of test vehicles and test intervals in the Ethyl test program, the same cannot be said of the Ethyl test results.

28/ Id. at 6.

b. Ford Escorts

Equally curious are the results for the Ford Escorts. A graph of the Ford test results show that both the clear and the one Additive-fueled vehicle that had not been involved in a serious accident had essentially the same increases in HC emissions from 5000 to 20,000 miles.[29/] The vehicle sets also performed comparably after 55,000 miles, both pairs actually showing a slight improvement in HC emissions out to 105,000 miles.[30/] The difference in HC emissions for the two sets of vehicles occurred for some reason in the mileage interval from 20,000 to 55,000 miles, and in the case of the wrecked vehicle, from 5000 to 55,000 miles.

What is especially curious about this result is that it stands in sharp contrast to the performance of the Ford Explorers. As noted above, most of the deterioration in HC emissions for the Ford Explorers using the Additive occurred from 55,000 to 105,000 miles.[31/] For the Escorts, most of the deterioration occurred from 20,000 to 55,000 miles.

[29/] See id., Figure 1. Vehicle 318 was involved in an accident at approximately 10,000 miles requiring the replacement of the engine, catalyst and EGO sensors. The severity of the accident calls into question the "representativeness" of this vehicle's emissions. Indeed, Ethyl doubts that Ford would ever attempt to certify a vehicle using test cars with rebuilt engine and emission system components.

[30/] Id.

[31/] Id., Figure 2.

Ford has yet to explain why the two test models showed such different emission patterns. The Escort data, for example, is inconsistent with Ford's theory that the Additive has a deteriorative effect which increases with mileage.[32/] Yet the Explorer data would be inconsistent with any theory explaining why abnormal deterioration should occur before 55,000 miles as reflected in the Escorts. Moreover, if as Ford alleges, the Additive causes deterioration in the performance of catalytic converter systems, why does the Ford data show comparable CO emissions for clear and Additive-fueled vehicles?[33/]

There are simply too many anomalies in the Ford data for them to be given much, if any, evidentiary weight. As Ethyl recognized at the public hearing, applicants for a fuel additive waiver have the burden of providing data in support of the § 211(f)(4) standard. There is also, however, a burden on those, such as MVMA, who comment in opposition to a waiver application -- the data they supply must withstand equally close scrutiny. Based on the available data, the recent Ford test program does not withstand such scrutiny.

[32/] R.G. Hurley, et al., The Effect on Emissions and Emission Control Component Durability by the Fuel Additive Methylcyclopentadienyl Manganese Tricarbonyl (MMT), Docket No. IV-D-01, at 9.

[33/] Appendix 3, Figures 5 and 6.

B. Even If the Agency Accords Some Weight to the Ford Test Program, the Results of the Ford Test Program Further Establish that Use of the Additive Will Not Cause or Contribute to the Failure of Emission Control Devices to Meet Applicable Emission Standards.

As noted above, the results of the Ford test program merit little evidentiary weight regarding the emission effects attributable to the Additive with respect to the national car fleet. Even if, however, the Agency determines that the Ford test program merits some consideration, the Ford test results do not in any way undermine Ethyl's contention that use of the Additive will not cause or contribute to the failure of emission control devices to meet applicable emission standards. This result is apparent from applying EPA's traditional cause or contribute test to the Ford test data.

As discussed in Ethyl's waiver application, the cause or contribute test is the basic test used by the Agency in approving waiver applications.[34/] This test addresses the impact of any change in exhaust emissions on compliance with applicable emission standards by a test fleet. In particular, it evaluates whether any adverse emissions effect "causes or contributes" to a failure of the test fleet to meet applicable emission standards.

Application of this test to the Ford test data suggests that use of the Additive did not cause or contribute to the failure of the emission control devices in the Ford test vehicles to meet applicable emission standards. All test vehicles, both those using clear fuel and those using fuel containing the Additive,

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[34/] 1990 Waiver Application at 13-15.

pass the applicable CO and NOx emission standards at all mileage intervals. With respect to the HC standards, all of the Ford test vehicles using fuel containing the Additive, with one exception, remain within the applicable HC standards at all mileage intervals.[35/] These results are presented in the following table.

[35/] Ford has indicated that the Explorers used in its test program were 1991 production vehicles having 1991 emission control technology, but a 1993 "production prototype" engine. See Transcript at 21. Because the prototype engine has not yet been certified to meet any particular emission standards under § 206 of the Act, test results for the "prototype" Explorer are not directly relevant to Ethyl's waiver application under the express terms of § 211(f)(4). See 42 U.S.C. § 7545(f)(4)(new fuel and fuel additives must not "cause or contribute to a failure" of a vehicle's emission control devices and systems "to achieve compliance . . . with the emission standards with respect to which it [the vehicle] has been certified pursuant to section 206.")(Emphasis added). The only standards for which the Explorer using 1991 production components, including the catalytic converter system, has been "certified" are the 1991 light-duty truck emission standards. Application of the 1991 standards to the Explorer is consistent with Ford's decision to report total HC data (as opposed to data on non-methane HC emissions) and Ford's acknowledgment that only one vehicle in the test fleet "failed applicable emission standards after 100,000 miles with MMT." MVMA Testimony at 1. This suggests that the applicable HC standard is the 0.8 gpm total HC standard applicable to 1991 light-duty trucks.

Cause or Contribute Test
Ford Test Results

	Emission Standards[36]		
Vehicle[37]	HC	CO	NOx
304	F	P	P
305	P	P	P
306	P	P	P
307	P	P	P
315	P	P	P
316	P	P	P
317	P	P	P
318	P	P	P

Since all vehicles meet the CO and NOx standards, there is, by definition, no cause or contribute effect shown for these pollutants. A single failure of the HC standard in a test "fleet" comprised of only two car models does not constitute a statistically significant effect for purposes of the cause or contribute test.[38] Thus, far from contradicting the results of Ethyl's test program, the results of the Ford test program provide additional evidence in support of the fundamental conclusion derived from the Ethyl test program -- i.e., use of

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[36] "P" denotes compliance with the standard. "F" denotes failure to comply.

[37] Vehicles 304, 306, 316, and 318 used fuel containing the Additive. Vehicles 305, 307, 315, and 317 used clear fuel.

[38] See Appendix 2 at 3. As SAI explains, Ford designed a test program incapable of answering whether use of the Additive causes or contributes to the failure of emission control devices to meet applicable emission standards. This is the direct result of testing only two car models. No matter how well or how poorly these models performed, no statistically significant conclusions about emission performance can be made because the confidence in such conclusions cannot exceed 25 percent. For a conclusion to be statistically significant, it must have a confidence level of at least 95 percent.

the Additive will not cause or contribute to the failure of emission control devices or systems to meet applicable emission standards.

III. THE QUESTIONS LISTED BY MVMA REGARDING ETHYL'S TEST PROGRAMS AND ANALYSES LACK MERIT.

In addition to describing the results of the Ford test program, MVMA has also submitted a series of questions and comments concerning the data in Ethyl's waiver application. As the Agency is aware, Ethyl's waiver application contains an immense amount of information on the Additive and numerous test programs that have been run by independent firms on behalf of Ethyl. The amount of information supplied in support of this waiver application far exceeds any information offered in any other waiver proceeding. Reflecting the comprehensive nature of the filings in this case, MVMA's questions are, for the most part, already addressed in materials submitted to the docket. To assist MVMA in its review of this material, and to set the record straight, the sections below provide a point-by-point response to MVMA's questions and indicate, as appropriate, where the materials of interest to MVMA appear in Ethyl's waiver application and supporting documents.

A. The Absence of Detergents in Ethyl's Test Fuel

MVMA asserts that "the lack of detergent additives in Ethyl's mileage accumulation gasoline impacted the HC emission results . . . [which] would have been greater if the vehicles had been fueled with a gasoline containing a deposit control

detergent additive."[39/] In other words, MVMA suggests that the absence of a detergent in the Ethyl test program and use of a fuel containing a detergent additive in the Ford test program may account for the apparent difference in emission results for the two test programs. MVMA's assertion is wrong.

First, MVMA's assertion makes little sense conceptually. Even if use of detergents affected "baseline" emissions,[40/] it does not follow that it would also affect the "relative" emission difference between a test fuel with and without the Additive. Indeed, as discussed below, it would probably not in the case of Howell EEE.

The purpose of detergent additives in commercial fuel is to minimize the accumulation of fuel system deposits on fuel injectors and other engine components, which could have an effect on emission performance.[41/] Howell EEE test fuel, however, is a very "clean" fuel that does not contribute to engine deposits.[42/] Since the test fuel was clean, the presence or absence of detergents would not be expected to have a material effect on the formation of fuel system deposits. If anything, one would think that the absence of a detergent in the Ethyl test

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[39/] See MVMA's Review of Ethyl Corporation's Application for Fuel Additive Waiver Dated July 12, 1991, Docket No. IV-F-5, at 2.

[40/] See Ford Reply Comments at 8.

[41/] Transcript at 14.

[42/] Ethyl Reply Comments at 31-32.

fuel would make the Ethyl test program a "worst case" program, since there would be no detergent to inhibit the formation of manganese deposits (one of the auto industry's primary concerns with the Additive).[43/]

Indeed, as part of the 48-car test program, Ethyl evaluated whether such deposits were affecting emissions. Photographs of fuel injectors and pistons taken from vehicles in the 48-car test fleet show very little deposit formation after 50,000 to 75,000 miles of vehicle operation on the Howell EEE test fuel.[44/] Based on these results, use of Howell EEE fuel without a detergent additive cannot reasonably be deemed to have affected baseline clear fuel emissions, as MVMA claimed, so as to make them unrepresentative.

Second, Ethyl informed both EPA and the three major domestic automobile companies that it intended to use Howell EEE test fuel for both mileage accumulation and emissions testing prior to commencement of the 48-car test program.[45/] Neither the Agency,

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[43/] See Transcript at 16 ("it sounds like not having a detergent additive in the test fuel would tend to provide higher hydrocarbon emissions and therefore a higher level in the Ethyl test program than in your test program") (question raised by Richard Wilson, Director of the Office of Mobile Sources).

[44/] Ethyl Reply Comments, Appendix 2 ("Technical Response to Comments Submitted by Ford and Chrysler").

[45/] Id., Appendix 1 ("Ethyl Memoranda Concerning Meetings With EPA and the Automobile Companies on the Design of the Test Protocol").

nor the auto companies, objected to use of Howell EEE at that time.[46/]

The decision to use Howell EEE fuel for both mileage accumulation and emissions testing resulted from Ethyl's efforts to minimize the number of variables introduced into the test program. Operating 48 vehicles for a total of 75,000 miles each consumes a great deal of gasoline. The specifications of commercial gasoline fuel stocks vary by manufacturer (in terms of detergent additives, etc.) and batch-to-batch, depending upon the season of the year. The only way to maintain the consistency of the fuel used in the test program, therefore, was to use a certification fuel, such as Howell EEE, where the specifications of the fuel remain constant.

Third, emissions data from other test programs involving use of the Additive do not suggest that use of a detergent together with the Additive in unleaded gasoline leads to abnormally high increases in HC emissions. The results of Ethyl's high speed Corvette test program, for example, show no significant differences in HC emissions in a pair of Corvettes operated on commercial fuel containing a detergent for a total of 25,000 miles.[47/] After 25,000 miles of operation at a constant speed

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[46/] Id.

[47/] See 1991 Waiver Application, Appendix 8 ("High-Speed Corvette Catalyst Durability Test"), Table II.

of 100 miles per hour, the difference in HC emissions for the two Corvettes was only 0.009 gpm.[48/]

Finally, the Coordinating Research Council ("CRC") testing in the late 1970s used a commercial fuel containing a detergent additive (Chevron fuel like that used by Ford) without generating HC emission increases of the magnitude apparently shown by the Ford testing or showing deterioration in emissions which increased as mileage increased.[49/] More recently, emission testing has been completed by a number of laboratories, including EPA's Ann Arbor lab, using a variety of commercial gasolines with and without the Additive, including ARCO, Texaco premium, and a Clean Air Act baseline fuel with gasohol and MTBE fuel additives. For each of these commercial fuels, use of the Additive had no effect on emissions.[50/]

For these reasons, there is simply no basis upon which to reasonably conclude that the presence or absence of detergents in fuel containing the Additive has any effect on the conclusions drawn from Ethyl's 48-car test program.

[48/] Id.

[49/] See Appendix 3 at 4. While the specific results of the dated CRC study are not illustrative of the Additive's effect on emissions in the current national car fleet due to substantial changes in automotive engineering technology, the CRC study provides data on emission trends which cast doubt on the Ford test results.

[50/] 1991 Waiver Application, Appendices 2 (Memorandum re: Review of Specific Fuel Effects on Tailpipe Emissions) and 4 ("Fuel-Specific Gaseous/Particulate Emission Test Program").

B. Fuel Injector Replacement

In commenting on Ethyl's test program, MVMA also suggests that Ethyl's decision to replace fuel injectors at the 50,000 mileage interval may have been prompted by abnormal deposit formation caused by the absence of a detergent additive in the test fuel.[51] This was not the case.

Ethyl decided to replace all fuel injectors with new injectors to determine specifically whether use of Howell EEE test fuel without an additive "fouled" the multi-port injectors. As part of this investigation, Ethyl measured emissions from the test vehicles both before and after replacement of the injectors.[52] SAI conducted a statistical analysis of these emissions measurements which showed that there was no statistically significant difference in emissions between the two sets of injectors.[53] This analysis shows that the use of the

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[51] See MVMA Testimony at 4.

[52] Fuel injectors in one of the Dodge Dynastys (Vehicle D-4) were replaced at approximately 40,000 miles due to malfunctioning. See 1990 Waiver Application, Appendix 1 ("Fleet Test Protocol"); Attachment 1-15. While Ethyl had proposed to remove injectors from only some of the test vehicles to evaluate the fouling issue, SAI advised Ethyl that, from a statistical evaluation standpoint, it would be better to remove injectors from all vehicles rather than from only some of the vehicles. See 1990 Waiver Application, Appendix 2A ("Statistical Analysis of Automotive Exhaust Emissions in Support of Ethyl's HiTEC 3000 Fuel Waiver Application") at 8. This would allow for better statistical evaluation of subsequent mileage accumulation.

[53] See id., Appendix 2A ("Statistical Analysis of Automotive Exhaust Emissions in Support of Ethyl's HiTEC 3000 Waiver Application"), Attachment G.

Additive, as well as the absence of detergents in the test fuel had no effect on fuel injectors in the test vehicles.

In addition, Southwest Research Institute ("SWRI") examined the fuel-flow characteristics of fuel injectors for one clear and one Additive-fueled vehicle from each test model used in Ethyl's 48-car test program. This analysis showed no significant differences in fuel flow between the clear and Additive-fueled injectors, further confirming that neither the Additive, nor the absence of a detergent package in the baseline test fuel, had an effect on emissions performance.[54/]

C. Driving Cycle Differences

MVMA also speculates that Ford's use of a different mileage accumulation cycle may have affected test results.[55/] The 48-car test program used the mileage accumulation driving cycle required for the certification of vehicles under the Agency's regulations.[56/] By contrast, the Ford program used a driving cycle the average speed of which was almost two times higher than the average speed in the certification durability driving cycle.

The Agency's waiver application guidelines require use of the certification mileage accumulation cycle. Use of the certification driving cycle cannot, therefore, be deemed to be a

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[54/] A copy of the fuel injector flow analysis is Appendix 4 ("Fuel Injector Inspection") to these comments.

[55/] MVMA Testimony at 3.

[56/] See 1990 Waiver Application, Appendix 1 ("Fleet Test Protocol").

valid basis for questioning the results of fuel additive emission testing.[57/]

Moreover, as noted above, design of the 48-car test fleet protocol did not occur in a vacuum. Before initiating the test program, Ethyl met with EPA and the auto industry to describe the test protocol in detail, including the driving cycle to be used.[58/] No one voiced concerns about use of the driving cycle at that time.

Finally, it is unlikely that differences in driving cycle would cause the dramatic differences in emissions claimed by Ford. For example, emission testing completed by Ethyl using the Additive in an extreme, high speed mileage accumulation driving cycle (100 mph constant speed for 25,000 miles) did not generate differences in emissions comparable to those shown in the Ford data.[59/]

D. Break-in Period Differences

MVMA asserts that Ethyl did not apply "a break-in period for all vehicles to stabilize emissions."[60/] Once again, this claim is incorrect.

[57/] See 43 Fed. Reg. at 11259.

[58/] Ethyl Reply Comments, Appendix 1 ("Ethyl Memoranda Concerning Meetings with EPA and the Automobile Companies on the Design of the Test Protocol").

[59/] See 1990 Waiver Application, Appendix 8 ("High-Speed Corvette Catalyst Durability Test"), Table II.

[60/] MVMA Testimony at 3.

Ethyl accumulated 1000 miles on each of the 48 test vehicles in its test fleet on Howell EEE to stabilize emissions before assigning a test fuel to each vehicle and beginning mileage accumulation with the Additive.[61/] This 1000 mile break-in is consistent with the Agency's certification regulations.[62/] Moreover, Ethyl specifically reviewed this aspect of the test protocol with EPA. Finally, as acknowledged by the Agency, "the [auto] industry [has] expressed its belief that a vehicle's emission performance stabilizes, in many cases, with significantly less mileage accumulations than 4000 miles."[63/] The difference in the break-in periods in the Ford and Ethyl programs therefore would not cause any significant difference in emissions.

E. Number of Emission Tests Per Mileage Interval

MVMA asserts that the Ford test program is more statistically significant "overall," since Ford conducted more emission measurements per test vehicle at each mileage test interval (six versus a minimum of two in the Ethyl test program). As noted above, however, this difference in test protocol is far less significant than Ford's decision to dramatically limit the number of test vehicles and test intervals in its test program

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61/ See 1990 Waiver Application, Appendix 1 ("Fleet Test Protocol").

62/ See 46 Fed. Reg. 50464, 50469 (1981).

63/ Id. at 50469, col. 3.

when compared to the Ethyl test program.[64/] As a result, the Ford program provides much less useful emissions information than the Ethyl program.

F. Differences in mileage accumulation

MVMA claims that "Ethyl's test fleet may not have accumulated sufficient mileage to adequately demonstrate that emission control systems are not adversely affected for the entire useful life." MVMA's assertion is incorrect.

All of the vehicles in Ethyl's 48-car test fleet were certified to meet applicable emission standards for a statutory useful life period of 50,000 miles. Ethyl's testing met this requirement and, indeed, continued an additional 25,000 miles for a total of 75,000 miles of operation for each test vehicle.

By testing at each 5000 mile interval up to 75,000 miles, the test data show clear emission trends. The emission data show little change in HC emissions after 50,000 miles, and continuing decreases in the relative NOx and CO emissions in cars using the Additive. There is nothing in the test data to suggest that this trend would not continue beyond 75,000 miles.

Finally, as reported in an earlier submission to the docket, Ethyl conducted 100,000 mile emission testing on four Chevrolet Corsicas. After 100,000 miles of operation, the vehicles operating on fuel containing the Additive met the applicable HC and NOx emission standards, while both the clear and Additive-fueled Corsicas failed the CO standard. With respect to the

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64/ See supra at 8-10.

durability of the catalysts after 100,000 miles, backpressure measurements for the vehicles using the Additive were no different than those for the vehicles using clear fuel, and catalyst converter efficiencies for the Additive-fueled vehicles were as good as, or better than, those for the clear fuel vehicles.[65/] These data confirm that there is no unusual emission variability associated with use of the Additive after 75,000 miles.

G. Statistical Analysis of the Test Data

Perhaps the most troubling mischaracterization of Ethyl's test data presented by MVMA was the suggestion that Ethyl subjectively determined what data to include for purposes of statistical analysis. This was not the case. Ethyl's waiver application and supporting documents provide a detailed discussion of the data set used in the analysis, in order to respond to precisely the type of question raised by MVMA.

As noted by SAI, the independent consultant that conducted the primary statistical analysis of Ethyl's 48-car test fleet data, "decisions on what data to include in the working data sets for analysis for this waiver application were based on the sections of the Code of Federal Regulations that pertain to

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[65/] See 1990 Waiver Application, Appendix 3 ("Durability Testing, Materials Compatibility Testing, Evaporative Emissions, Drivability, and Particulate Emissions"), at 6-7.

certification and test procedures for exhaust emissions."[66/] Reflecting these requirements, Appendix 2A of Ethyl's May 9, 1990 submission provides a detailed description of SAI's approach to generation of the data set for purposes of its statistical analysis.[67/]

This description makes clear that the data set used in the SAI analysis was generated, not at Ethyl's direction, but based upon the decision of the independent experts specifically to comply with existing regulatory requirements applicable to the statistical treatment of emissions data used to certify automobiles under the CAA and sound statistical protocols.[68/] There was nothing "subjective" about this treatment of the emissions data.[69/]

In fact, SAI categorically rejects MVMA's suggestion that the failure to include all the data in the analyses was improper,

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66/ 1990 Waiver Application, Appendix 2A ("Statistical Analysis of Automotive Exhaust Emissions in Support of Ethyl's HiTec 3000 Waiver Application"), at 10.

67/ A copy of the pertinent section of the SAI statistical analysis from Appendix 2A is attached as a part of Appendix 1.

68/ Appendix 1, Attachment 1 (For example, SAI explains that "[a]ll zero-mile tests are excluded, as per 40 CFR 86.088-28(a)(4)(i)(A)(1)," and "[t]ests preceding unscheduled maintenance are excluded per 40 CFR 86.88-28.").

69/ Indeed, the decision to conduct the statistical analyses using only the first two emission tests at each mileage interval enhanced the objectivity of the analysis because, as SAI recognized, the decision to conduct additional emission tests at various mileage intervals was made on a case-by-case basis. See Appendix 2 at 2.

or may have skewed their analysis.[70] SAI also believes that inclusion of all the data would not have changed any of the conclusions reflected in SAI's statistical analysis.[71] MVMA's allegation is simply misguided, and does not provide any basis to question SAI's determination that use of the Additive does not cause or contribute to the failure of emission control systems to meet applicable emission standards.

H. Canadian Warranty Return Data

MVMA suggested that catalytic converter warranty replacement rates are higher in Canada than in the U.S. and that this difference may be attributable to use of the Additive in Canada.

First, Ethyl has never seen, nor does the record contain, warranty replacement data suggesting a higher incidence of catalytic converter replacement in Canada than in the U.S. The automobile industry's allegations with respect to warranty replacement have to date been entirely anecdotal.

The only non-anecdotal data of any relevance on this issue of which Ethyl is aware is reported in Appendix 10 to Ethyl's July 23, 1990 submission to the docket. A working group from the Canadian General Standards Board, in a study of the Additive's use in Canada, reported that "[m]embers of MVMA and AIC

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[70] Id. at 1.

[71] Id. at 2.

[Automotive Importers of Canada] indicate that Canadian warranty claims on emission components are comparable to the U.S."[72/]

I. Freon® Contamination

Another troubling comment by MVMA relates to the emission test results generated by EPA's Ann Arbor laboratory using test fuel contaminated by Freon® 12. MVMA suggests that the presence of the contaminant in the test fuel had no effect on HC emission test results. The suggestion that test results generated using contaminated fuel should be used in evaluating the Additive is curious, and raises serious questions as to the motives and credibility of MVMA. Indeed, most of the issues raised by MVMA appear to be intended to raise doubt about the carefully designed 48-car test program. It is difficult to take many of these questions seriously.

The Agency itself has recently confirmed that the fuel it used for testing the Additive had been contaminated with Freon®

72/ Comments in Support of the Waiver Application for the HiTEC 3000 Performance Additive (July 23, 1990), Appendix 10 ("An Assessment of the Effect of MMT on Light-Duty Vehicle Exhaust Emissions in the Canadian Environment"), at 6 (emphasis added). It should also be noted that any warranty replacement data would be difficult to interpret, if they actually exist. For example, Canadian law allows use of the Additive at a higher concentration (1/16 gram per gallon) than is proposed in Ethyl's waiver application. In addition, Canada does not have a rigorous inspection and maintenance program, as does the U.S., raising questions as to whether any higher warranty replacement rate in Canada can in fact be attributed to the Additive. Finally, the use of leaded gasoline in Canada through 1990 raises questions regarding the potential for misfueling vehicles. In the absence of hard data which takes these considerations into account, the automobile industry's anecdotal accounts of warranty differences between the U.S. and Canada are entitled to little, if any, weight.

12.[73/] The Agency has also completed testing which shows that the presence of Freon® 12 in test fuel substantially increases HC emissions.[74/] Testing by other independent laboratories confirms this result.[75/]

For the automobile industry to suggest that test results generated using contaminated test fuel are in any way relevant to this waiver application directly undercuts their credibility, because it illustrates to what lengths the auto industry is prepared to go in their attempt to attack the Additive.[76/] Ethyl has little doubt that the automobile industry's position as to the relevancy of emission testing based on the use of contaminated test fuel would be strikingly different were the Agency to initiate a vehicle recall action based on emission results generated using a contaminated test fuel.

[73/] Letter from Tom Schrodt, Correlation and Engineering Services, U.S. EPA to Don Hollrah, Ethyl Petroleum Additives, Inc. dated August 13, 1991. A copy of Mr. Schrodt's letter is Appendix 5 to these comments.

[74/] Id.

[75/] 1991 Waiver Application, Appendix 5A ("Analysis of EPA Test Fuel") at 5-9.

[76/] As MVMA well knows, Ethyl has not sought a waiver application for fuel containing a combination of the Additive and Freon® 12. For this reason, emission testing of fuel containing both the Additive and Freon® is irrelevant to a decision on Ethyl's waiver application.

J. Oxygen Sensors

MVMA also speculates that use of the Additive adversely affects the performance of oxygen sensors.[77/] MVMA's idle speculation on this point, however, is entitled to no weight. Ethyl conducted a detailed test program to investigate this very concern and failed to find any adverse effect for the oxygen sensors used in Ethyl's 48-car test fleet program.[78/] MVMA provides no hard evidence which would call into question the results of Ethyl's oxygen sensor test program.

K. Catalytic Converter Durability

The following Ethyl test programs have uniformly shown that use of the Additive does not adversely affect catalytic converter operation:

- Evaluation of the catalytic conversion efficiencies of the emission control systems of the 48 cars in Ethyl's test fleet after the accumulation of 1000 miles, 50,000 miles and 75,000 miles.[79/]
- Evaluation of exhaust back pressures for the vehicles from the 48 car test fleet after 75,000 miles of operation.[80/]
- Catalyst durability testing extended (i) over 100,000 miles in four General Motor Corsicas, (ii) 25,000 miles (at 100 miles per hour constant speed) on a pair of General Motor

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77/ MVMA Testimony at 2.

78/ See 1990 Waiver Application, Appendix 3 ("Durability Testing, Materials Compatibility Testing, Evaporative Emissions, Driveability, and Particulate Emissions") at 2-3.

79/ Id. at 3-5.

80/ Id. at 5.

Corvettes, and (iii) 35,000 miles at up to 80 miles per hour on a pair of Ford Crown Victorias.[81/]

- Evaluation of 24 catalysts from Ethyl's 48-car test fleet using a common "slave" engine to supply inlet gases and to minimize the variables potentially affecting catalytic converter efficiencies other than exposure to manganese.[82/]

Notwithstanding the extensive information Ethyl has provided to the Agency showing that use of the Additive does not cause plugging of catalytic converters or otherwise adversely affect their performance, the MVMA panel continues to make allegations regarding plugging.

MVMA's principal comment now focuses on the high speed Corvette testing conducted at Ethyl's request.[83/] MVMA speculates that the extremely small increase in backpressure in the Additive-fueled Corvette (0.7 inch-Hg relative to a baseline of approximately 16.5 inch-Hg for the clear fuel vehicle)

[81/] Id. at 5-7; 1991 Waiver Application, Appendix 8 ("High-Speed Corvette Catalyst Durability Test").

[82/] 1991 Waiver Application, Appendix 7 ("Slave Engine/Dynamometer Catalyst Studies at SWRI").

[83/] MVMA also attempts to discredit the results of Ethyl's slave engine testing by asserting that "Ethyl's data show decreases in converter efficiency." See MVMA's Review of Ethyl Corporation's Application for Fuel Additive Waiver Dated July 12, 1991, Docket No. IV-F-5, at 3. MVMA is simply playing with the numbers here, attempting to claim that 92 percent versus 94 percent efficiency represents a 33 percent increase in HC emissions [i.e., (8% inefficiency - 6% inefficiency) ÷ 6% inefficiency = 33% increase]. This comment is ridiculous and again demonstrates the length to which MVMA will go in trying to raise doubt about Ethyl's test program. The proof of catalyst performance is the on-car testing which shows no detriment (and some enhancement) of converter efficiency with use of the Additive. The slave engine testing completed by SWRI merely confirms Ethyl's on-car testing. See 1991 Waiver Application, Appendix 7 ("Slave Engine/Dynamometer Catalyst Studies at SWRI") at 4.

observed in this program after operating the vehicles at 100 miles per hour constant speed for 25,000 miles would, if extrapolated to 100,000 miles of operation, increase back pressure to 4.4 inch-Hg.[84/] This claim is specious.

First, such a small difference in backpressure cannot be attributed to use of the Additive given the normal variability in the backpressure test procedure. This variability exists from measurement-to-measurement and from vehicle-to-vehicle. For example, backpressure measurements for the clear fuel Corvette in Ethyl's test program varied by 0.6 inch-Hg from one measurement to the next at the 25,000 mile interval.[85/] Similarly, the backpressure of the clear fuel vehicle was 0.3 inch-Hg less than the Additive-fueled vehicle before initiation of mileage accumulation.[86/] Given this wide variability, MVMA's attempt to attribute importance to a 0.7 inch-Hg difference in backpressure is misguided.

Second, one MVMA panelist expressly recognized that extrapolation of this nature is a questionable practice, especially where the extrapolation takes such an extremely small

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[84/] Transcript at 19.

[85/] 1991 Waiver Application, Appendix 8 ("High-Speed Corvette Catalyst Durability Test") at Table I.

[86/] Id.

difference and uses it to make predictions at a mileage point that is far-removed.[87/]

Third, another MVMA panelist, the General Motors representative, acknowledged that General Motors had conducted "rapid aging tests" with close-coupled Corvette catalysts. As reported by General Motors, the results of this testing showed "no statistical difference in the efficiency across the catalysts with and without [the Additive]."[88/] This suggests that the Additive does not cause catalyst plugging -- the same conclusion suggested by the back pressure measurements in Ethyl's high speed Corvette testing.

Finally, the high speed Corvette test program completed by Ethyl was designed to reflect "worst-case" operating conditions for use of the Additive based on prior auto industry comments. The Corvettes have a close-coupled catalyst which (due to the severity of the driving cycle) were subjected to inlet gas temperatures approximating 800-850 degrees Celsius. Earlier comments by Ford suggested that the Additive would be most prone to plug catalysts under these conditions.[89/] The fact that no plugging was evident in the Corvette catalysts under such a

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[87/] Transcript at 32 ("There are obvious problems with extrapolating linearly . . . .").

[88/] Transcript at 25.

[89/] See Letter to Air Docket from D.R. Buist, Ford Motor Company, Docket No. IV-D-59, at 4.

severe driving cycle further confirms that use of the Additive will not harm catalytic converter operation.

In combination with all of the other test programs listed above (which MVMA has not directly challenged), the high speed Corvette testing clearly establishes that catalyst plugging is no longer an issue in this proceeding.

L. Reactive HC Emissions

In another clear example of MVMA's efforts to obfuscate rather than clarify the issues, MVMA takes issue with what it mischaracterizes as "Ethyl's claim that use of HiTEC 3000 would '. . . lower reactive hydrocarbon emissions by 23 to 30 percent and lower regulated toxic emissions by 13 to 28 percent.'"[90/] Rather than drawing such precise conclusions, Ethyl has suggested only that the direction and magnitude of the changes observed in this speciation testing shows that the Additive "could be very helpful in meeting new fuel requirements."[91/]

Nor, as MVMA claims, are such results obtained only where xylenes have been added to the clear test fuel to equalize octane.[92/] For example, Ethyl also measured reactivity and

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[90/] MVMA's Review of Ethyl Corporation's Application for Fuel Additive Waiver Dated July 12, 1991, Docket No. IV-F-5, at 2 (emphasis added).

[91/] See 1991 Waiver Application, Overview at 8.

[92/] Ethyl's use of an aromatic (xylene) to equalize octane in its initial speciation test program is fully consistent with the commercial practices of the refining industry. Refiners have repeatedly indicated in comments to the Agency on Ethyl's waiver application that aromatics, including xylenes, will be reduced

(continued...)

toxic emissions from test vehicles using Howell EEE fuel with and without the Additive, where the Additive was simply "splash blended" into the test fuel. While total HC emissions were 14 percent lower in the test vehicle using the Additive, the reactivity and toxicity of the emissions were even lower -- 28 percent on both counts.[93/] This clearly shows that the benefits in terms of reactivity and toxic emissions shown using test fuels of equal octane was not simply a function of using xylene to

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[92/] (...continued)
with use of the Additive in commercial operation. For example, the National Petroleum Refiners Association, whose members include virtually every refiner and petrochemical manufacturer in the U.S., has commented that use of the Additive would "save energy required for high severity processing that would otherwise be required to achieve higher octane levels, at the same time reducing the quantity of less desirable by-products." Letter to EPA from Urvan Sternfels, President, National Petroleum Refiners Association dated July 23, 1990 (docket entry IV-D-52). This conclusion has been echoed by large and small refiners alike in comments to docket A-90-16. See, e.g., Letter to EPA from G.A. Hickman, Vice President, Longview Refining Associates, Inc., dated July 20, 1990 (docket entry IV-D-60) (Use of the Additive "would permit us to lower our reformer severity thereby lowering the level of aromatics in our gasoline."); Letter to EPA from Jeff Hart, President, MAPCO Petroleum, Inc., dated July 12, 1990 (docket entry IV-D-26) (Use of the Additive would "[r]educe [the] level of aromatics in gasoline."); Letter to EPA from Dennis McCormick, Executive Vice President, Wyoming Refining Company, dated July 18, 1990 (docket entry IV-D-61) (Use of the Additive "would allow us to lower our reformer severity thus lowering the level of aromatics in our gasoline."): Letter to Air Docket from Jerry Jenkins, Vice President, Fina Oil and Chemical Company, dated July 20, 1990 (docket entry IV-D-62) ("HiTec 3000 will reduce aromatic content of gasoline."): Letter to EPA from J.P. Chamberlain, Vice President and CEO, American International Refinery, Inc., dated July 20, 1990 (docket entry IV-D-63) (Use of the additive would lower "the level of aromatics in our gasoline.").

[93/] See 1991 Waiver Application, Appendix 18 ("Reformulated Gasoline and the Beneficial Effects of HiTEC 3000"), Table 2.

equalize the octane. Ethyl's test results suggest that the use of the Additive alone can reduce the reactivity and toxicity of unleaded gasoline emissions.

M. Manganese and Public Health

Playing the role of public health advocate, MVMA purports to be troubled by a single airborne manganese measurement obtained by Ethyl for an eight-hour period in a parking garage in Toronto, Ontario, because it was equivalent to the inhalation reference concentration ("RfC") established by EPA's Office of Research and Development ("ORD") for manganese.[94/] MVMA's comment ignores the context for this measurement, all other monitoring and modeling data offered by Ethyl and others, and the results of EPA's public symposium on manganese.

Airborne manganese concentrations in microenvironments (such as that for a parking garage) are relevant to public health only insofar as those concentrations affect the daily inhalation exposure to manganese. The measurement of concern to MVMA was taken in a parking garage over an eight hour period of heavy traffic, designed to produce an extreme, worst-case

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[94/] MVMA's Review of Ethyl Corporation's Application for Fuel Additive Waiver Dated July 12, 1991, Docket No. IV-F-5, at 1. With respect to the RfC itself, Clement International, noted health risk experts, has argued that ORD improperly incorporated a modifying factor of three in deriving the RfC. See 1991 Waiver Application, Appendix 13 ("Comments on EPA/ORD Risk Assessment for MMT Use in Unleaded Gasoline") at 6-7. Appendix 6 to these comments provides a brief analysis of the Roels study (the study on which the RfC is primarily based) which further supports this claim.

measurement.[95/] It is not reasonable to assume that individuals would spend 24-hours a day in an enclosed parking garage for a lifetime, the time period upon which the RfC is based. As the Agency itself recognizes, exposure to airborne pollutants in parking garages would generally be very brief.[96/] The effect of manganese exposure in a parking garage on average daily manganese exposure, would be extremely small, and would not raise average daily airborne manganese exposures to anywhere near the level of the manganese RfC.[97/]

Ford's separate comments to the docket on manganese and public health appear to be based entirely on outdated information and analyses.[98/] For example, Ford's analysis is based entirely

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[95/] 1991 Waiver Application, Appendix 13 ("Comments on the EPA/ORD Risk Assessment for MMT Use in Unleaded Gasoline"), Attachment 5, at 2.

[96/] See Comments on the Use of Methylcyclopentadienyl Manganese Tricarbonyl in Unleaded Gasoline, Office of Research and Development, U.S. EPA, November 1, 1990 at 33, Table 3-2.

[97/] 1991 Waiver Application, Appendix 13 ("Comments on the EPA/ORD Risk Assessment for MMT Use in Unleaded Gasoline"), Attachment 5.

[98/] Indeed, Ethyl cannot help but wonder if Ford has even reviewed any of the extensive submittals to the docket concerning manganese and public health made by Ethyl and others since mid-1990. For example, Ford cites manganese emission testing completed by Ethyl which showed that only about 0.4 percent of the manganese in the fuel was emitted, even though Ethyl has based all of its manganese exposure analyses on 30 percent manganese emissions. While Ethyl has no reason to question directly the results of this initial testing, subsequent testing by Ethyl and others, including EPA and Ford, show that manganese emissions associated with use of the Additive would generally fall in the 10 to 15 percent range. Although Ethyl's recent waiver application reflects the results of this more recent

(continued...)

on ORD's preliminary health risk and exposure assessment for manganese which ORD itself now acknowledges overestimated manganese exposure associated with use of the Additive.[99/] Ford's "health" claims are therefore at best, misinformed.

Finally, it should be noted that the results of Ford's particulate test program further confirm the conservatism of Ethyl's manganese exposure analyses. Ethyl's exposure analyses assume that as much as 30 percent of the manganese in the fuel is emitted as airborne manganese particulate. Ford's particulate test results, by contrast, show that, on average, only about 13 percent of the manganese in the fuel is emitted -- a result consistent with the 10 to 15 percent emissions generated by EPA's Ann Arbor test laboratory, SWRI, and ECS.[100/] Thus, the Ford particulate analysis further confirms Ethyl's contention that use of the Additive will not adversely affect public health.

IV. CONCLUSION

Ethyl has expended great effort in designing a test program from which scientifically valid conclusions can be drawn about the Additive. After nearly one and one-half years of analysis, no one has yet been able to challenge directly the fundamental

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98/ (...continued)
testing, Ford cites only the initial manganese emission results reported by Ethyl well over one year ago.

99/ 1991 Waiver Application at 42, n. 114.

100/ Ford reports that manganese emissions range from 6 to 45 percent of the manganese in the test fuel, without reporting average emissions. Ford Particulate Analysis at 8.

data or conclusion from that test program -- i.e., use of the Additive will not cause or contribute to the failure of emission control systems to meet applicable emission standards. Lacking a means to challenge directly the Ethyl data, opponents have been forced to rely on limited, ad hoc testing to raise questions about the Additive.

Past experience in this proceeding clearly establishes that limited ad hoc testing is <u>not</u> a reliable method for obtaining accurate information about the Additive. The only way to draw valid conclusions about the Additive is through carefully designed testing, and the only carefully designed test program on the Additive is that which has been completed by independent laboratories on behalf of Ethyl. Based on this extensive body of information, the Agency should act promptly to approve this waiver application.

ETHYL CORPORATION

Health and Environment Department

Donald R. Lynam, Ph.D.
Director, Air Conservation
and Industrial Hygiene

October 2, 1991

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Cable Address: ETHYLBR
TELEX 586-441

OVERNIGHT MAIL

Mr. David L. Kulp
Manager, Fuel Economy
Planning & Compliance
Ford Motor Company
The American Road
Dearborn, Michigan 48121

Dear Mr. Kulp:

In accordance with your request for additional test data from the Ethyl test fleet, we are enclosing the data dropped from Ethyl data set 2S (136 data points) and 4S (151 data points). The Systems Applications, Inc. final report, entitled "Appendix 2A: Statistical Analysis of Automotive Exhaust Emissions in Support of Ethyl's HiTEC® 3000 Fuel Waiver application," May 4, 1990, and included in the May 9, 1990 Waiver Submission, includes a complete discussion of the data sets and data set generation in Section 2, Testing Program Data Base. The discussion of data set generation and description of data sets is attached (pages 10-15). The 136 data points dropped from Ethyl 2S are all tests invalid from an engineering point of view and therefore are considered justifiable drops. The 151 data points dropped from Ethyl 4S are the extra tests beyond the standard first two emission tests. The data sets are fully described in the SAI report. Please let us know if additional clarification is required.

We wanted to thank you for sending us the raw data from Ford Motor Company's ("Ford") recent test program on the HiTEC® 3000 performance additive. To aid us further in evaluating Ford's raw data, Ethyl would like to learn more about the Ford test program. In particular, we believe that the following information will be necessary for a meaningful evaluation of the data:

- Any available maintenance information in addition to that which was provided as part of the raw emission data sheets you provided to Ethyl. This would include information on both scheduled and unscheduled maintenance, reason for service, listing of components replaced and why the decision to replace was made.

- Identification of individual drivers for each emission test and for each test vehicle, including the process used to assign drivers to test vehicles.

- A description of the type and purpose of the test programs (including test protocols) on which the Additive testing was piggybacked.

- Listing of fuel batch numbers, fuel analysis and specifications, detergent, and other additives. Samples of test fuel, if available, would also be helpful.

- A detailed description of the Explorer "prototype" vehicle, including the thermactor being tested and purpose, and applicable emission standards calibration.

- Individual data on emission tests for CO, HC, NO_x, particulates, and manganese obtained in the particulate cells as part of the particulate analysis, together with mileage test points, and dates of testing.

- Information on mileage accumulation shifts, including number of shifts per day, length of shifts, and the approximate total number of hours the vehicles are driven per day.

- Any data on the driveability of the test vehicles throughout the course of the test program.

In addition, once you have completed your ongoing test programs, we would appreciate information and data on any post mortem analyses of vehicle components, including catalysts, O_2 sensors, fuel injectors, and any other engine parts. We look forward to receiving more details about the Ford test program.

Sincerely,

Donald R. Lynam

Donald R. Lynam, Ph.D., CIH, PE
Director, Air Conservation,
Industrial Hygiene and Safety

DRL:cr
Enclosures
cc: Mary T. Smith
Field Operations and Support
229drl91

Excerpt from

Final Report

APPENDIX 2A: STATISTICAL ANALYSIS OF AUTOMOTIVE EXHAUST EMISSIONS IN SUPPORT OF ETHYL'S HiTEC® 3000 FUEL WAIVER APPLICATION

SYSAPP-90/037

May 4, 1990

Prepared for

Ethyl Petroleum Additives, Inc.
20 South 4th Street
St. Louis, Missouri 63102

Prepared by

Systems Applications, Inc.
101 Lucas Valley Road
San Rafael, California 94903

415/472-4011

DATA SET GENERATION

Special attention was given to the creation of the data sets for analysis. This step is important because it defines the information used in the statistical tests and its presentation in the waiver.

In 43 Federal Register 11258 (March 17, 1978) the EPA published a series of guidelines that apply to waiver applications for fuel additives under Section 211(f) of the Clean Air Act. In these guidelines the EPA states that "it is essential that test data provide a reliable basis for comparison with the conditions under which vehicles are certified pursuant to Section 206 of the Clean Air Act." Throughout this waiver program it has been generally assumed by Ethyl that the regulations that apply to the certification of new automobile models under the Clean Air Act would also apply to test programs for fuel waivers. For that reason, decisions on what data to include in the working data sets for analysis for this waiver application were based on the sections of the Code of Federal Regulations that pertain to certification and test procedures for exhaust emissions (40 CFR Part 86 as of January 31, 1990).

Because of the importance placed on those specific sections of the Code of Federal Regulations, we shall discuss several of the specific paragraphs that are relevant to this waiver application.

> 86.088-28(a)(4)(A) "The applicable results to be used unless excluded by paragraph (a)(4)(i)(A)(4) of this section in determining the exhaust emission deterioration factors for each engine-system combination shall be:
>
> 1. All valid exhaust emission data from the tests required under 86.084-26(a)(4) except the zero-mile tests.
>
> 2. All exhaust emission data from the tests conducted before and after the scheduled maintenance provided in 86.088-25.
>
> 3. All exhaust emission data from tests required by maintenance approved under 86.088-25, in those cases where the Administrator conditioned his approval for the performance of such maintenance on the inclusion of such data in the deterioration factor calculation.

4. The manufacturer has the option of applying an outlier test procedure to completed durability data.... The outlier procedure will be specified by the Administrator. For any pollutant, durability-data test points that are identified as outliers shall not be included in the determination of deterioration factors if the manufacturer has elected this option."

Comments: These paragraphs imply that all emissions test results except those associated with the zero-mile point and those conducted before unscheduled maintenance be used in the statistical analysis. This would include all results obtained before and after scheduled maintenance and after unscheduled maintenance. Examination of the data in the initial stages of analysis revealed no outliers, and so no tests were deleted as a result of an outlier test procedure.

86.084-26(a)(6)(i)(A) "The manufacturer may conduct multiple tests at any test point at which the data are intended to be used in the deterioration factor. At each test point where multiple tests are conducted, the test results from all valid tests shall be averaged to determine the data point to be used in the deterioration factor calculation except under paragraph (a)(6)(i)(B) of this section. The test results from emission tests performed before maintenance affecting emissions shall not be averaged with test results after the maintenance".

86.084-26(a)(6)(i)(B) "The manufacturer is not required to average multiple tests if the manufacturer conducts no more than three tests at each test point and if the number of tests at each test point is equal. All test points must be treated the same for all exhaust pollutants".

86.088-28(a)(4)(i)(B) "All applicable exhaust emission results shall be plotted as a function of the mileage on the system, rounded to the nearest mile, and the best fit straight lines, fitted by the method of least squares, shall be drawn through all these data points".

Comments: The implication of the first two paragraphs is that the means for each car at each testing interval should be weighed equally. This assumes that the mean emissions for each individual vehicle is the same as that for all vehicles in the same model group on the same fuel. Therefore careful consideration must be given to those instances where there are a different number of tests per car per testing interval. When the design is balanced (i.e., the same number of tests for each vehicle at each testing interval), the same regression line will be predicted whether one uses all the data or just the averages (although confidence intervals will be

different). However, in a design that is unbalanced the predicted regression line using all data will differ from that predicted from one using average data.

DESCRIPTION OF DATA SETS

The data sets used in the statistical analyses to examine whether HiTEC 3000 causes or contributes to the failure of emission control systems were generated from raw data supplied to SAI (as Lotus 123 spreadsheets) by the mileage accumulation test laboratories. The data sets were constructed sequentially, each data set being a sub-set of the previous data set. The data sets created and the emissions tests excluded at each step are as follows:

ETHYL0S Data set as received from the mileage accumulation test laboratory. No records are excluded, except one test for the replacement vehicle designated D3A: the single test of D3A at 15,554 miles (initial mileage upon receipt). All tests of the replacement car with the old car's emissions control system (labeled as D3A) are included.

ETHYL1S All zero-mile tests are excluded, as per 40 CFR 86.088-28(a)(4)(i)(A)(1).

ETHYL2S All tests that are invalid from an engineering point of view and therefore considered to be "justifiable drops" are excluded. These include the 1,000 mile tests conducted at Automotive Testing Laboratories whose exclusion is justifiable on both statistical and engineering grounds (See Appendix 1 and Attachment F). Also dropped in this data set are all measurements from vehicle D3A.

ETHYL3S Tests preceding unscheduled maintenance tests are excluded per 40 CFR 86.088-28.

ETHYL4S Extra tests beyond the standard two tests are excluded. If these tests were included, the variance calculations for the statistical tests would be biased. These are the tests that were performed because the results from the first two tests were considered to be too discrepant. In the

majority of instances the mileage intervals have only two tests per vehicle. In data set ETHYL3S, for example, only about 25 percent of the testing intervals have extra tests. There are three types of exceptions to this use of only two tests at each mileage interval. First, at scheduled maintenance (35,000 miles and 60,000 miles for model group D; 30,000 miles and 60,000 miles for all other model groups), emissions were tested before and after maintenance; thus for these intervals there are typically four tests (two before and two after maintenance). Second, tests performed after unscheduled maintenance are considered separately from tests at the required mileage intervals. For example, vehicle H1 has four tests at the 40,000 mile interval -- two for the unscheduled maintenance at 37,826 miles and two for the regular 40,000 mile tests. Third, tests were performed before and after 50,000 mile component changes. At this mileage point there are typically four tests (two before and two after component changes).

On October 12, 1989 a meeting was held in Washington, D.C. with representatives from the EPA's Office of Mobile Sources to review the statistical analysis work that had been completed to date. At that meeting a presentation was made and discussion held on the relevant sections of the Code of Federal Regulations, the data sets generated, and the justification for dropping data points based on the interpretation of the CFR. Following this review, the EPA indicated that the approach taken seemed "reasonable".

ADDITIONAL DATA SETS FOR 75,000 MILE ACCUMULATION

As mentioned above, the original design of the HiTEC 3000 testing program called for only 50,000 accumulated miles and emissions testing in accordance with current requirements under Section 211(f) of the Clean Air Act. The scope of the testing program was increased to include 75,000 miles of vehicle operation in light of the ongoing debate concerning reauthorization of the Act.

Because of the change in mileage accumulation, certain aspects of the testing program that had been completed needed to be reviewed to insure that the data past

50,000 miles would be internally consistent with data up to and including 50,000 miles. The aspect that most obviously demanded evaluation was the component changes that had occurred at 50,000 miles. As discussed earlier, these changes were made to determine what effects on tailpipe emissions were the result of the deterioration of components up to 50,000 miles. An analysis of the data following the 50,000 mile component changes indicated that, in general, statistically significant increases in emissions from vehicles occur about as frequently as statistically significant decreases in emissions; however some changes were substantially larger than others (see Attachment G). For example, in model group D a very large and statistically significant decrease in CO emissions occurred with both fuel types. Further, the vehicles in this model group fueled with HiTEC 3000 also exhibited a statistically significant decrease in HC emissions after component changes. In addition, in model groups G and H, increases in HC and CO emissions from vehicles using HiTEC 3000 were found to be statistically significant, while increased emissions from vehicles using the clear fuel (Howell EEE) were nonsignificant. These changes can be seen in the data plots in Attachment B.

The change in mileage accumulation scope also required reevaluation of tester bias. As discussed previously, most of the pre-50,000 mile tests at ECS were performed by one individual. Tests after 50,000 miles were conducted by other ECS testers while the original tester was on sick leave. This change raised the question of whether emission test results were affected in any way by the use of several testers. If a tester bias did exist, it would be more difficult to estimate how much of the variance between results was associated with the fuel type as opposed to the tester. Again, an analysis was conducted to determine if tester choice had statistically significant effects on test results. For example, a statistical test was performed on model group D for HC. The results from this test, as well as those for other model groups, are reported in Attachment H and indicate that statistically significant differences from the original tester are evident in many model groups and for all three pollutants.

In order to properly and consistently analyze all of the data from the mileage accumulation program to 75,000 miles, three new data sets were created from data set ETHYL4S. These data sets, which are adjusted for component change and tester effects, are as follows:

ETHYL4S2 The two emissions tests performed after the component changes at 50,000 miles are deleted for all vehicles in the program. The tests performed before component changes are retained.

ETHYL4S3 Adjustments for component changes are calculated from the statistical analysis discussed in Attachment G (the effect for each pollutant/fuel/model combination is calculated separately as the mean effect across vehicles) for all measurements past 50,000 miles.

ETHYL4S4 Adjustments for tester effects at ECS Laboratories are added to all measurements after 50,000 miles in data set ETHYL4S2. Details of the analysis are provided as Attachment H.

The main data set for assessing the effects of HiTEC 3000 is ETHYL4S2; a complete listing of this data set is provided as Attachment A. Some analysis was repeated on ETHYL4S, ETHYL4S3, and ETHYL4S4, with little change in results or interpretation. The results are described in detail in Section 4.

The numbers of emissions tests read, kept, and dropped in each data set are shown below:

Data Set	Read	Kept	Dropped
ETHYL0S	2605	2604	1
ETHYL1S	2604	2440	164
ETHYL2S	2440	2304	136
ETHYL3S	2304	1965	339
ETHYL4S	1965	1814	151
ETHYL4S2	1814	1712	102

Data Set ETH4SPRG 1

OBS	Model	Vehicle ID	Fuel	Mileage	HC (g/mi)	CO (g/mi)	NOx (g/mi)
1	D	D2	EEE	45,094	0.658	5.322	0.469
2	D	D4	HT3	35,161	0.645	3.505	0.427
3	D	D4	HT3	40,133	0.616	4.162	0.413
4	D	D4	HT3	44,786	0.580	4.908	0.416
5	D	D4	HT3	50,166	0.581	3.490	0.417
6	D	D4	HT3	50,184	0.607	3.619	0.384
7	D	D5	HT3	35,049	0.579	4.459	0.452
8	D	D5	HT3	45,151	0.740	4.943	0.551
9	D	D5	HT3	48,433	0.924	4.960	0.441
10	D	D5	HT3	48,444	0.796	4.617	0.404
11	D	D6	HT3	35,152	0.550	3.979	0.437
12	D	D6	HT3	45,113	0.646	5.790	0.480
13	D	D6	HT3	49,985	0.680	6.173	0.476
14	E	E2	EEE	45,090	0.266	6.490	0.415
15	E	E2	EEE	50,181	0.323	7.928	0.531
16	E	E3	EEE	30,048	0.175	4.573	0.291
17	E	E5	HT3	40,048	0.214	4.963	0.424
18	E	E6	HT3	50,040	0.199	6.250	0.396
19	F	F1	HT3	49,943	0.688	1.747	0.582
20	F	F1	HT3	75,099	0.698	1.067	0.607
21	F	F2	HT3	30,401	0.571	1.240	0.640
22	F	F2	HT3	45,067	0.608	1.251	0.764
23	F	F2	HT3	50,040	0.614	1.364	1.173
24	F	F3	HT3	15,118	0.392	0.757	0.727
25	F	F3	HT3	45,128	0.610	1.274	0.687
26	F	F3	HT3	67,052	0.578	1.623	0.840
27	F	F3	HT3	67,070	0.573	1.248	0.764
28	F	F4	EEE	1,045	0.169	0.398	0.485
29	F	F4	EEE	45,052	0.745	2.897	1.060
30	F	F4	EEE	45,070	0.651	2.413	1.390
31	F	F4	EEE	50,126	0.668	2.830	1.442
32	F	F4	EEE	55,006	0.653	4.909	1.808
33	F	F5	EEE	50,118	0.596	2.253	0.978
34	F	F5	EEE	50,166	0.618	1.939	1.037
35	F	F5	EEE	66,536	0.515	2.284	1.097
36	F	F5	EEE	66,554	0.482	2.131	1.141
37	F	F6	EEE	30,170	0.645	1.878	0.816
38	F	F6	EEE	34,995	0.505	1.518	0.699
39	F	F6	EEE	45,216	0.700	2.145	0.779
40	F	F6	EEE	50,042	0.715	2.470	0.870
41	T	T1	HT3	24,968	0.383	3.843	0.508
42	T	T1	HT3	45,004	0.417	5.017	0.536
43	T	T1	HT3	50,078	0.516	6.576	0.665
44	T	T2	EEE	45,124	0.381	4.400	0.579
45	T	T2	EEE	50,044	0.491	6.735	0.873
46	T	T3	EEE	25,004	0.300	3.718	0.707
47	T	T3	EEE	50,037	0.420	6.710	0.801
48	T	T4	HT3	1,149	0.188	1.555	0.488
49	T	T4	HT3	5,273	0.248	2.632	0.465
50	T	T5	HT3	24,994	0.360	4.172	0.430
51	T	T5	HT3	40,082	0.441	5.648	0.596
52	T	T6	EEE	5,215	0.224	1.992	1.034
53	C	C1	EEE	20,090	0.243	2.233	0.373

OBS	Model	Vehicle ID	Fuel	Mileage	HC (g/mi)	CO (g/mi)	NOx (g/mi)
54	C	C1	EEE	35,135	0.156	1.916	0.301
55	C	C1	EEE	35,165	0.149	1.954	0.320
56	C	C2	HT3	20,090	0.198	2.160	0.314
57	C	C2	HT3	30,100	0.206	2.644	0.185
58	C	C2	HT3	30,180	0.209	3.360	0.234
59	C	C2	HT3	50,059	0.221	4.004	0.379
60	C	C2	HT3	60,123	0.206	2.979	0.546
61	C	C3	HT3	15,064	0.258	2.911	0.229
62	C	C3	HT3	20,059	0.199	2.118	0.246
63	C	C3	HT3	25,073	0.249	3.308	0.437
64	C	C3	HT3	30,060	0.240	3.382	0.266
65	C	C3	HT3	30,131	0.182	2.102	0.238
66	C	C3	HT3	35,058	0.260	2.629	0.181
67	C	C3	HT3	35,112	0.269	2.129	0.193
68	C	C3	HT3	40,064	0.240	3.064	0.200
69	C	C3	HT3	50,058	0.251	2.956	0.290
70	C	C3	HT3	65,056	0.254	3.244	0.307
71	C	C4	EEE	20,074	0.202	1.708	0.446
72	C	C4	EEE	35,059	0.156	1.849	0.414
73	C	C5	EEE	20,066	0.159	2.277	0.228
74	C	C5	EEE	45,060	0.173	2.327	0.248
75	C	C6	HT3	20,065	0.237	2.417	0.259
76	C	C6	HT3	30,073	0.194	2.126	0.233
77	C	C6	HT3	40,086	0.192	2.199	0.250
78	C	C6	HT3	50,060	0.171	1.953	0.235
79	C	C6	HT3	55,082	0.162	2.228	0.323
80	C	C6	HT3	60,050	0.186	2.333	0.296
81	G	G1	EEE	5,080	0.091	0.981	0.223
82	G	G1	EEE	51,110	0.137	3.234	0.395
83	G	G1	EEE	55,064	0.106	2.465	0.361
84	G	G1	EEE	63,738	0.216	2.632	0.343
85	G	G1	EEE	63,757	0.182	2.222	0.326
86	G	G1	EEE	65,120	0.175	2.637	0.346
87	G	G1	EEE	65,139	0.164	2.518	0.317
88	G	G2	EEE	40,112	0.213	2.194	0.363
89	G	G2	EEE	55,067	0.129	2.408	0.389
90	G	G2	EEE	60,085	0.109	2.543	0.402
91	G	G3	HT3	51,110	0.183	2.248	0.390
92	G	G3	HT3	60,060	0.178	2.883	0.401
93	G	G4	EEE	51,104	0.132	2.194	0.365
94	G	G5	HT3	51,132	0.283	2.192	0.357
95	G	G5	HT3	60,124	0.153	2.140	0.422
96	G	G6	HT3	51,118	0.169	2.350	0.369
97	G	G6	HT3	55,065	0.174	2.026	0.352
98	G	G6	HT3	55,439	0.121	1.262	0.319
99	G	G6	HT3	55,466	0.074	1.352	0.266
100	G	G6	HT3	55,491	0.121	1.660	0.381
101	G	G6	HT3	60,064	0.187	1.709	0.386
102	G	G6	HT3	65,061	0.191	2.946	0.367
103	H	H1	EEE	30,063	0.281	3.671	0.347
104	H	H1	EEE	55,068	0.327	4.883	0.338
105	H	H1	EEE	55,094	0.481	5.067	0.405
106	H	H1	EEE	55,113	0.417	4.760	0.398

OBS	Model	Vehicle ID	Fuel	Mileage	HC (g/mi)	CO (g/mi)	NOx (g/mi)
107	H	H1	EEE	55,131	0.436	4.712	0.397
108	H	H2	EEE	20,059	0.241	3.097	0.345
109	H	H2	EEE	30,108	0.350	4.169	0.308
110	H	H2	EEE	30,161	0.321	3.724	0.325
111	H	H2	EEE	35,099	0.317	3.974	0.311
112	H	H2	EEE	50,095	0.374	5.004	0.458
113	H	H2	EEE	55,119	0.339	4.964	0.436
114	H	H2	EEE	75,128	0.373	3.801	0.414
115	H	H3	HT3	20,091	0.230	2.108	0.544
116	H	H3	HT3	30,146	0.247	2.707	0.438
117	H	H3	HT3	45,058	0.305	3.858	0.376
118	H	H3	HT3	50,107	0.335	3.625	0.387
119	H	H3	HT3	55,101	0.356	5.103	0.301
120	H	H4	HT3	20,063	0.249	2.190	0.673
121	H	H4	HT3	45,061	0.305	4.443	0.476
122	H	H4	HT3	55,075	0.321	4.145	0.326
123	H	H5	EEE	30,109	0.228	2.347	0.451
124	H	H5	EEE	30,225	0.229	2.380	0.509
125	H	H5	EEE	55,063	0.336	5.179	0.429
126	H	H6	HT3	30,127	0.381	4.469	0.303
127	H	H6	HT3	40,063	0.323	3.885	0.331
128	H	H6	HT3	45,088	0.420	4.126	0.271
129	H	H6	HT3	50,159	0.358	4.867	0.379
130	H	H6	HT3	50,688	0.428	4.908	0.388
131	H	H6	HT3	55,058	0.467	5.027	0.267
132	I	I1	EEE	25,093	0.170	2.282	0.353
133	I	I1	EEE	50,110	0.180	2.779	0.384
134	I	I1	EEE	50,379	0.167	2.768	0.438
135	I	I2	HT3	5,845	0.204	2.561	0.266
136	I	I2	HT3	15,301	0.178	2.237	0.505
137	I	I2	HT3	15,334	0.233	3.496	0.510
138	I	I2	HT3	30,066	0.200	2.615	0.349
139	I	I2	HT3	30,166	0.181	2.317	0.350
140	I	I2	HT3	50,278	0.212	2.401	0.301
141	I	I3	EEE	25,075	0.178	2.157	0.374
142	I	I4	HT3	30,067	0.215	1.766	0.291
143	I	I4	HT3	45,061	0.156	1.966	0.311
144	I	I4	HT3	50,431	0.158	2.329	0.311
145	I	I5	EEE	25,072	0.179	2.460	0.395
146	I	I5	EEE	35,076	0.181	2.224	0.333
147	I	I5	EEE	50,386	0.176	2.240	0.428
148	I	I6	HT3	35,064	0.186	1.965	0.361
149	I	I6	HT3	35,908	0.236	2.446	0.374
150	I	I6	HT3	40,066	0.193	2.082	0.333
151	I	I6	HT3	50,326	0.182	2.123	0.604

Data Set ETH2SPRG 1

OBS	Model	Vehicle ID	Fuel	Mileage	HC (g/mi)	CO (g/mi)	NOx (g/mi)
1	D	D3	EEE	7,486	0.394	1.723	0.317
2	D	D3	EEE	7,502	0.408	2.063	0.292
3	D	D3	EEE	9,833	0.380	2.683	0.330
4	D	D3	EEE	9,851	0.385	2.379	0.325
5	D	D3	EEE	15,157	0.419	2.694	0.328
6	D	D3	EEE	15,175	0.519	3.289	0.319
7	D	D3	EEE	15,202	0.527	3.469	0.412
8	D	D3	EEE	19,801	0.707	4.178	0.319
9	D	D3	EEE	19,820	0.616	3.658	0.239
10	D	D3	EEE	19,854	0.563	3.376	0.281
11	D	D3	EEE	24,944	0.955	4.614	0.369
12	D	D3	EEE	24,961	0.685	4.248	0.301
13	D	D3	EEE	24,980	0.778	4.273	0.323
14	D	D3	EEE	25,007	0.569	4.139	0.340
15	D	D3	EEE	25,024	0.612	3.836	0.340
16	D	D3	EEE	29,758	0.583	4.353	0.295
17	D	D3	EEE	29,777	0.588	3.909	0.316
18	D	D3	EEE	29,795	0.487	3.608	0.260
19	D	D3	EEE	29,814	0.649	3.995	0.321
20	D	D3	EEE	29,832	0.563	4.023	0.324
21	D	D3	EEE	34,842	0.565	4.816	0.361
22	D	D3	EEE	34,859	0.596	6.233	0.403
23	D	D3	EEE	34,877	0.613	5.466	0.424
24	D	D3	EEE	39,786	0.600	6.777	0.400
25	D	D3	EEE	39,804	0.543	5.490	0.386
26	D	D3	EEE	39,823	0.589	5.853	0.441
27	D	D3	EEE	44,794	0.561	4.912	0.332
28	D	D3	EEE	44,813	0.596	5.576	0.375
29	D	D3	EEE	50,076	0.652	6.022	0.411
30	D	D3	EEE	50,095	0.706	5.858	0.354
31	D	D3	EEE	50,114	0.615	5.477	0.372
32	D	D3	EEE	50,132	0.619	6.039	0.433
33	D	D3	EEE	50,147	0.747	5.464	0.387
34	D	D3	EEE	50,249	0.564	4.427	0.370
35	D	D3	EEE	50,267	0.525	3.691	0.367
36	D	D3	EEE	50,285	0.535	3.802	0.383
37	D	D3	EEE	50,302	0.545	3.509	0.365
38	D	D3	EEE	54,891	0.613	4.808	0.365
39	D	D3	EEE	54,910	0.483	4.280	0.370
40	D	D3	EEE	59,969	0.742	6.805	0.563
41	D	D3	EEE	59,988	0.761	7.304	0.577
42	D	D3	EEE	60,006	0.601	5.774	0.382
43	D	D3	EEE	60,024	0.555	4.942	0.303
44	D	D3	EEE	64,963	0.741	7.397	0.422
45	D	D3	EEE	64,982	0.677	7.247	0.466
46	D	D3	EEE	69,971	0.663	5.742	0.417
47	D	D3	EEE	69,990	0.564	4.953	0.367
48	D	D3	EEE	74,769	0.624	5.333	0.394
49	D	D3	EEE	74,787	0.682	4.961	0.336
50	D	D3	EEE	74,806	0.711	5.449	0.394
51	D	D3	EEE	74,824	0.653	4.560	0.398
52	E	E6	HT3	35,025	0.267	5.229	.
53	F	F1	HT3	50,086	0.719	1.576	0.632

OBS	Model	Vehicle ID	Fuel	Mileage	HC (g/mi)	CO (g/mi)	NOx (g/mi)
54	C	C1	EEE	1,053	0.129	1.917	0.164
55	C	C1	EEE	1,081	0.128	1.836	0.207
56	C	C1	EEE	1,099	0.150	1.328	0.210
57	C	C1	EEE	1,119	0.180	1.842	0.221
58	C	C1	EEE	1,184	0.133	1.311	0.148
59	C	C2	HT3	1,051	0.134	1.912	0.165
60	C	C2	HT3	1,072	0.115	1.712	0.160
61	C	C2	HT3	1,091	0.133	1.380	0.190
62	C	C2	HT3	1,118	0.172	1.702	0.232
63	C	C2	HT3	30,070	0.207	2.452	0.191
64	C	C2	HT3	30,100	0.206	2.664	0.185
65	C	C3	HT3	1,058	0.173	2.989	0.199
66	C	C3	HT3	1,078	0.141	2.353	0.240
67	C	C3	HT3	1,097	0.146	2.272	0.166
68	C	C3	HT3	1,137	0.156	1.807	0.199
69	C	C3	HT3	1,157	0.157	1.781	0.244
70	C	C4	EEE	1,050	0.145	1.937	0.125
71	C	C4	EEE	1,069	0.139	2.034	0.155
72	C	C4	EEE	1,089	0.120	1.808	0.200
73	C	C4	EEE	1,139	0.134	1.164	0.187
74	C	C4	EEE	1,155	0.133	1.041	0.245
75	C	C5	EEE	1,054	0.166	2.619	0.156
76	C	C5	EEE	1,081	0.136	1.956	0.130
77	C	C5	EEE	1,100	0.154	2.739	0.141
78	C	C5	EEE	1,120	0.156	1.948	0.178
79	C	C5	EEE	1,140	0.148	2.109	0.151
80	C	C6	HT3	981	0.166	2.152	0.179
81	C	C6	HT3	1,008	0.118	1.830	0.204
82	C	C6	HT3	1,028	0.132	1.843	0.175
83	C	C6	HT3	1,076	0.144	1.565	0.212
84	G	G1	EEE	1,030	0.090	0.870	0.158
85	G	G1	EEE	1,059	0.114	1.109	0.169
86	G	G1	EEE	1,091	0.127	2.145	0.161
87	G	G2	EEE	1,038	0.084	0.698	0.169
88	G	G2	EEE	1,079	0.080	0.898	0.162
89	G	G2	EEE	5,034	0.190	1.179	0.223
90	G	G2	EEE	30,143	0.128	2.321	0.394
91	G	G2	EEE	35,041	0.129	3.034	0.451
92	G	G3	HT3	1,041	0.086	0.801	0.185
93	G	G3	HT3	1,069	0.085	0.724	0.197
94	G	G3	HT3	30,116	0.235	1.662	0.350
95	G	G4	EEE	1,063	0.103	0.980	0.153
96	G	G4	EEE	1,090	0.079	0.695	0.136
97	G	G5	HT3	1,116	0.094	0.971	0.223
98	G	G5	HT3	1,143	0.090	1.052	0.217
99	G	G5	HT3	40,008	0.230	2.567	0.326
100	G	G5	HT3	45,006	0.212	2.711	0.326
101	G	G5	HT3	50,009	0.168	4.321	0.391
102	G	G6	HT3	1,087	0.084	0.953	0.209
103	G	G6	HT3	1,117	0.122	0.716	0.177
104	G	G6	HT3	45,039	0.175	3.055	0.382
105	G	G6	HT3	50,009	0.187	3.168	0.447
106	H	H1	EEE	1,048	0.126	1.130	0.435

OBS	Model	Vehicle ID	Fuel	Mileage	HC (g/mi)	CO (g/mi)	NOx (g/mi)
107	H	H1	EEE	1,087	0.162	1.749	0.449
108	H	H2	EEE	1,083	0.202	1.863	0.353
109	H	H2	EEE	1,103	0.208	1.830	0.372
110	H	H3	HT3	1,026	0.144	1.262	0.320
111	H	H3	HT3	1,075	0.165	1.585	0.349
112	H	H4	HT3	1,162	0.142	1.412	0.581
113	H	H4	HT3	1,182	0.165	1.646	0.549
114	H	H5	EEE	1,021	0.143	1.680	0.457
115	H	H5	EEE	1,056	0.154	1.692	0.395
116	H	H6	HT3	1,082	0.157	1.622	0.503
117	H	H6	HT3	1,101	0.158	1.618	0.431
118	I	I1	EEE	1,033	0.151	2.089	0.305
119	I	I1	EEE	1,072	0.151	2.136	0.411
120	I	I2	HT3	1,079	0.181	2.519	0.380
121	I	I2	HT3	1,098	0.168	2.251	0.399
122	I	I2	HT3	25,007	0.449	4.273	0.449
123	I	I2	HT3	25,032	0.317	3.142	0.486
124	I	I2	HT3	25,058	0.211	2.991	0.488
125	I	I3	EEE	1,038	0.179	2.095	0.167
126	I	I3	EEE	1,058	0.198	2.184	0.191
127	I	I4	HT3	1,034	0.133	1.489	0.178
128	I	I4	HT3	1,054	0.164	2.036	0.173
129	I	I4	HT3	25,008	0.374	3.117	0.384
130	I	I4	HT3	25,039	0.180	2.046	0.377
131	I	I4	HT3	25,067	0.302	2.754	0.350
132	I	I4	HT3	50,123	0.382	3.069	0.338
133	I	I5	EEE	1,065	0.139	1.694	0.383
134	I	I5	EEE	1,085	0.145	2.025	0.389
135	I	I6	HT3	1,060	0.122	1.702	0.275
136	I	I6	HT3	1,080	0.152	1.916	0.223

Systems Applications International

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A Division of Clement International Corporation
Environmental and Health Sciences

MEMORANDUM

TO: Ethyl Corporation

FROM: Alison Pollack and Jonathan Cohen

SUBJECT: Discussion of Ford comments and analysis of Ford data

DATE: 2 October 1991

We have reviewed Ford Motor Company's ("Ford") comments concerning the generation of the data sets used in System Applications International's ("SAI") statistical analysis of the emission data from Ethyl Corporation's ("Ethyl") 48-car testing program. We categorically disagree with the suggestion that SAI "subjectively" created a subset of data for statistical analysis that would generate statistical results favorable to Ethyl. We applied the statistical analyses to the data set which, in our view, complied with all applicable regulatory requirements regarding the certification of vehicles under the Clean Air Act and which provided the most "objective" view of the emission test results.

For the record, we repeat here the 75,000 mile data sets that were generated, the tests the were excluded in each, and the reasons for exclusion of tests:

ETHYL0S — Data as received from the test laboratories. No tests were excluded, except one test for the replacement vehicle designated D3A: the single test of D3A at 15,554 miles (initial mileage upon receipt). All tests of the replacement vehicle with the old vehicle's emission control system (labeled as D3A) are included.

ETHYL1S — 164 zero-mile tests were excluded, per 40 CFR 86.088-28.

ETHYL2S — 136 tests that are invalid from an engineering point of view are therefore considered to be "justifiable drops" were excluded.

ETHYL3S — 339 tests preceding unscheduled maintenance were excluded per 40 CFR 86.088-28.

ETHYL4S — 151 tests which were "extra" tests beyond the standard two were deleted.

Data set ETHYL4S was the main data set used for our statistical analyses. We still maintain that ETHYL4S is the proper data set on which to perform the analysis.

With respect to Ford's particular comments, SAI does not agree with Ford's assertion that it designed a test program that resulted in "increased statistically significant overall data" when compared to Ethyl's 48-car test program. Statisticians, when designing experimental test programs, have to consider all sources of uncertainty and how they will affect the outcome of interest. In the case of emissions testing from light-duty vehicles, test-to-test variability is by far the smallest source of variability. Car-to-car variability is much, much larger (often by orders of magnitude). The gain, in a statistical sense, increasing the number of tests from two or three per interval to six per interval is extremely small. A far better experimental design for Ford would have been to double the number of vehicles and halve the number of tests per interval. This is indeed why Ethyl chose a smaller number of tests per interval and a larger number of cars. Indeed, the phrase "statistically significant overall data" is not even meaningful.

Nor is Ford consistent in its comments on SAI's data set treatment. On the one hand, they say that there was "a subjective decision process as to the number of tests" per interval. On the other hand, they comment on the "subjective decision as to the inclusion of some test data". Ford is correct that decisions regarding extra tests were made by the emission testing laboratories on a case-by-case basis, and were subjective. For that very reason, the third (and later) tests were deleted for the statistical analysis of HiTEC 3000 effects to increase the overall objectivity of the analysis.

It is our belief that the conclusions to be drawn from Ethyl's 48-car test program would not change if the statistical tests were repeated using the data not included in SAI's reported analyses. SAI performed all statistical tests on versions of the 50,000 mile data corresponding to data sets ETHYL4S, ETHYL3S, and ETHYL2S. Specifically, we performed all statistical analyses on the 50,000 mile data on three data sets: (1) including the third (and more) tests, (2) adding to that tests preceding unscheduled maintenance, and (3) adding to that the tests considered invalid from an engineering point of view. The analyses on all three data sets showed no difference whatsoever in the statistical results or conclusions. Based on these analyses, and our understanding of the data, we believe that the same conclusions would be drawn if statistical analyses were repeated on all available data based on emission testing to 75,000 miles.

SAI's analysis of Ethyl's fleet data showed that HiTEC 3000 did not cause or contribute to the failure to meet emissions standards to which the vehicles were certified. This conclusion was based on what is known as the "cause or contribute" test, which we briefly describe here. Using statistical methods, one can estimate, from the set of measurements for a group of vehicles on a particular fuel, the percentage of vehicles that fail the standard at any

mileage point. If at any mileage point the estimated percentage failure rate for the additive fuel exceeds 10 percent and exceeds the estimated percentage failure rate for the non-additive fuel, then the additive is presumed to cause or contribute to the failure of vehicles in that vehicle group to meet applicable emissions standards. This is a cause or contribute test applied to a single vehicle group. A sign test is then used to determine if this failure occurs for a significant number of vehicle groups; this is the cause and contribute test for a set of vehicle groups. Recall that the statistical approach used to estimate the percentage of vehicles failing the standard is based on regression analysis, and that in SAI's analysis both linear and quadratic regression were used.

Ethyl requested that we conduct the same cause or contribute test on the raw data from Ford's recent test program. It is important to note in this regard that Ford's test design does not allow for a meaningful application of the cause and contribute test to their test "fleet." The cause and contribute test was originally developed as a sign test. Thus emissions from a number of vehicle groups, say N of them, are measured for base and test fuels and the number of vehicle groups for which the test fuel is deemed to cause or contribute to a failure to meet emissions standards is compared to N/2, where N/2 is the expected number of failures of this test if the test and base fuel have equal emissions on average. This statistical test is designed for fleets with a relatively large number of vehicle groups. In the Ford testing program, there are only two vehicle groups, and this sign test is inappropriate because it is far too likely to reach the wrong conclusion. With only two vehicle groups, if the test fuel has absolutely no adverse effect, the probability is at least 25 percent that the cause and contribute sign test would be failed.

We analyzed the Ford Escort and Explorer composite FTP data for all three regulated pollutants. Some of the Ford tests were omitted for these analyses. Since the Escort 318 is arguably like a new vehicle at 10,106 miles, after the accident repairs, all mileage tests with an odometer reading less than 15,000 were dropped and 10,106 miles were subtracted from the remaining odometer readings. Thus the three tests taken at 10,000 miles (just after the accident repairs) were treated as zero miles tests and therefore dropped. Additional maintenance-related emissions tests that were dropped for this analysis were the three tests prior to the 55,184 miles test for the Explorer 306 (spark plug changes), the first four tests at 105,000 miles for the same vehicle (fuel injector and spark plug replacement), and the 82,538 miles test for Escort 317 (throttle body replacement).

Because there are only two vehicle groups in the Ford data, and they are designed to meet different standards, one can perform individual cause and contribute tests on each vehicle group, but the overall sign test is inappropriate for the reasons stated above. Pollutant standards for the Escort are 0.41 g/mile hydrocarbons ("HC"), 3.4 g/mile carbon monoxide ("CO"), and 1.0 g/mile oxides of nitrogen ("NOx") at 50,000 miles. Standards for the Explorer, a prototype light-duty truck, are 0.8 g/mile HC, 10.0 g/mile CO, and 1.7 g/mile NOx at 100,000 miles.

Because the Escort is certified to 50,000 miles, all tests beyond the 55,000 mile group of tests (marked as 65,000 miles for the Escort 318) were dropped, and the cause and contribute test was applied using both linear and quadratic regressions and a certification mileage of 50,000 miles. For all six tests (three pollutants, using both linear and quadratic regression), the analyses showed that HiTEC 3000 did not cause or contribute to a failure to meet applicable emission standards.

For the Explorer analyses, tests through the 105,000 miles group were used, and the cause and contribute test was applied using both linear and quadratic regressions and a certification mileage of 100,000 miles. The test was passed for carbon monoxide and nitrogen oxides (using both linear and quadratic regression), and was failed for hydrocarbons using both linear and quadratic regression. However, the estimated failure mileages for hydrocarbons were very high: 91,000 miles for linear regression and 93,000 miles for quadratic regression. For additional information, the same analyses were repeated after dropping all data beyond 65,000 miles and assuming a 50,000 mile certification mileage. In these cases, no failures of the cause and contribute test occurred for any of the three regulated pollutants.

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Environmental and Health Sciences

TECHNICAL MEMORANDUM

TO: Ethyl Corporation
FROM: Ralph L. Roberson, P.E.
DATE: October 1, 1991
SUBJECT: Comments on Ford's Data and Experimental Design

INTRODUCTION

This memorandum addresses emission data obtained by Ford Motor Company and the experimental design used by Ford to obtain the data. Our comments are based on information submitted by Ford to EPA[1] and statements made by Ford during the September 12, 1991 public hearing regarding Ethyl's HiTEC 3000 wavier request.

EXPERIMENTAL DESIGN

During the public hearing, Ford stated that its experimental design resulted in "increased statistically significant overall data" because six emission tests were conducted on each car at each test interval. We strongly disagree with Ford's characterization of its experimental design.

In designing an experiment, one must consider all sources of variability and how the contribution of each source of variability will affect the experimental results. In the case of determining tailpipe emissions from mobile sources, our experience is that test-to-test variability for an individual vehicle is the smallest source of emission variability. Vehicle-to-vehicle and model-to-model variability are much, much greater than test-to-test variability.

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[1]Letter to Mary T. Smith, U.S. Environmental Protection Agency from David L. Kulp, Ford Motor Company dated September 23, 1991.

For a mathematical representation of the above discussion, consider the following. Suppose μ represents the true average emissions using some fuel at some mileage across a fleet of cars. We envision statistically the jth determination within the ith car as:

$$Y_{ij} = \mu + C_i + D_{ij}$$

where D_{ij} has a normal distribution with variance σ_D^2 and represents test-to-test variability (short-term variation); C_i has variance σ_C^2 and represents car-to-car variability.

A sample mean (average) of d determinations on c cars has variance:

$$\frac{\sigma_C^2}{c} + \frac{\sigma_D^2}{d \times c} \qquad [1]$$

Whether d = 6 determinations on c = 2 cars is better than d = 2 determinations on c = 6 cars depends on the formula involving σ_C^2 and σ_D^2. If $\sigma_C^2 = 2\sigma_D^2$, we see that:

$$\frac{2\sigma_D^2}{2} + \frac{\sigma_D^2}{12} > \frac{2\sigma_D^2}{6} + \frac{\sigma_D^2}{12}$$

Moreover, we see that if d x c = total number of observations is fixed, then testing more cars with less determinations on each will improve accuracy.

THE FORD DATA

Ford measured tailpipe emissions as a function of mileage for four Ford Escorts and four Ford Explorers. Two vehicles of each model accumulated mileage using the HiTEC 3000 additive, and two vehicles of each model accumulated mileage without HiTEC 3000. For the Escorts, Ford measured tailpipe emissions at 5,000; 20,000; 55,000; and 105,000 miles. The same mileage intervals were used for the Explorers, and three of the four Explorers

were also tested at 85,000 miles. At each mileage/test interval (except 85,000), Ford conducted six emission tests on each vehicles. Figures 1 through 6 (attached) present the emission test data for the Escorts and the Explorers. Note that Escort No. 318 was involved in an accident; the engine, catalyst, and oxygen sensor were replaced at 10,116 miles. We have subtracted 10,116 miles from the odometer readings for Escort No. 318 before plotting each emission value.

Hydrocarbon Emissions

Our first observation regarding Ford's HC data is the absence of emission data between 55,000 and 105,000 miles. Ford's six repetitions at each test interval does an excellent job of establishing tailpipe emissions for each vehicle at a given mileage point. However, six measurements at 55,000 and 105,000 miles provide no information on emissions for the intervening 50,000 miles.

Focusing on the data, HC emissions for the two Escorts using HiTEC 3000 (i.e., Vehicle Nos. 316 and 318) are clearly different from any emission data we have studied. Ford's data suggest a large increase in HC emissions for the HiTEC 3000 Escorts between 5,000 and 55,000 miles. However, after 55,000 miles, the difference in HC emissions for Escorts with and without HiTEC 3000 remains constant. Moreover, the slope of the HC curve for Escort 316 is generally the same as for the two non-HiTEC 3000 Escorts (No. 315 and 317).

Ford has postulated that the reason for differing results between Ethyl's Escorts and Ford's Escorts is that Ethyl failed to accumulate mileage with fuel that contains any type of detergent additive to minimize deposits. Furthermore, Ford stated that deposits would increase with increasing mileage and that the HiTEC 3000 effect on HC emissions would increase with increasing mileage. Apparently Ford developed its hypothesis before Ford considered the 105,000 mile HC data for the Escorts.

As noted above, neither the HiTEC 3000 nor the non-HiTEC 3000 Escorts show any deterioration in HC emissions from 55,000 to 105,000 miles.

Not only is Ford's hypothesis disproved by its own data, it is also inconsistent with data obtained by a Coordinating Research Council (CRC) study. While emission control technologies are different now than those employed at the time of the CRC tests, the CRC test data may be instructive with respect to emission trends in general. While we do not believe that the specific results of the dated CRC study are indicative of HiTEC 3000's effect on emissions in the current national car fleet, the CRC results nevertheless provide data on emission trends which can be compared to the Ford data. Also, the CRC test program used a fuel for mileage accumulation that contained a detergent additive to minimize deposits. The CRC data show an increase in HC emissions with HiTEC 3000 up to about 15,000 miles. Thereafter, the difference in HC emissions with and without HiTEC 3000 remains relatively constant. Thus, the CRC data, which incorporate the effect of a detergent additive, do <u>not</u> support the hypothesis that any effect that HiTEC 3000 has on HC emissions increases with increasing mileage.

Lastly, the Ford HC data for its fleet of four Escorts are inconsistent with the data obtained by Ethyl for its fleet of six Escorts. These inconsistencies are illustrated by Figure 1A. Figure 1A is a plot of HC emissions averaged across the non-HiTEC 3000 and the HiTEC 3000 fleets, respectively. It is strange how Ford's non-HiTEC 3000 Escorts perform so much better than those tested by Ethyl. Also note that non-HiTEC 3000 Escorts tested by Ford have lower HC emissions at 105,000 miles than at 55,000 miles. Such findings are, at best, unusual given that the vehicles are required to meet a HC emission limit only up to 50,000 miles.

The HC emission data obtained by Ford for its four Explorers are very difficult to unravel. First, one of the Explorers (No. 306) that did not use HiTEC 3000 exhibits incredible performance with respect to HC emissions. HC emissions increase by only 0.03 gm/mile from 5,000 to 55,000 miles. HC emissions increase by less than 0.08 gm/mile from 5,000 to 105,000 miles. Based on all HC measurements reported by Ford for this vehicle, HC emissions average 0.15 gm/mile, which is less than 20 percent of a 0.8 gm/mile emission standard. The obvious question: is this vehicle truly representative of Ford Explorers? Both Explorers that used HiTEC 3000 produce odd emission results. Explorer No. 306 (which used HiTEC 3000) shows a very small effect on HC emissions between 5,000 and 55,000 miles. HC emissions increase by about 0.03 gm/mile during this 50,000 mile interval. The next time Explorer No. 306 was tested (105,000 miles), HC emissions skyrocketed to about 1.38 gm/mile. The Ford data sheet indicates that an insulator on one of the spark plugs was found to be cracked and was subsequently replaced. Ford retested that vehicle and determined average HC emissions to be 0.656 gm/mile. Given that HiTEC 3000 is associated with an increase in HC emissions of about 0.03 gm/mile between 5,000 and 55,000 miles, it is simply unreasonable to ascribe a HC increase of almost 0.5 gm/mile between 55,000 and 105,000 miles to HiTEC 3000. It is much more plausible to believe that the spark plug problem identified by Ford has a significant impact on HC emissions, and this impact swamped any effect that can be attributed to HiTEC 3000.

The other Explorer using HiTEC 3000 (No. 304) also demonstrates a unusual trend in HC emissions. While HC emissions increase with increasing mileage up to 85,000 miles, HC emissions decrease by 0.16 gm/mile between 85,000 and 105,000 miles. Given that the vehicle is in the later part of its "useful life", it is difficult to reconcile a significant decrease in HC emissions -- with or without HiTEC 3000.

Nitrogen Oxides Emissions

The NO_x emission data for Ford's four Escorts are reasonably consistent with the results obtained by Ethyl for its six Escorts. [Ford reported no difference in CO emissions for HiTEC 3000 and non-HiTEC 3000 vehicles in the Ford test fleet.] Ford's data suggest HiTEC 3000 has little or no effect on NO_x emissions. This is consistent with the findings for the Escorts tested by Ethyl. The reader is reminded that some of the vehicle models evaluated by Ethyl did not show a reduction in NO_x emissions as a result of using HiTEC 3000 equivalent to the overall fleet average reduction in NO_x emissions. The Ford Escorts were one such model group. However, the Ethyl fleet as a whole, which consisted of eight model groups, demonstrated significantly lower NO_x emissions with HiTEC 3000.

Ford's NO_x emission data for its four Explorer's are very confusing. Both HiTEC 3000 vehicles (Nos. 304 and 306) show an initial (i.e., between 5,000 and 20,000 miles) decrease in NO_x emissions. Then, Explorer No. 306 appears to have problems with spark plug(s) and fuel injector(s). At the next test interval (55,000 miles), NO_x emissions are four times those determined at the 20,000 mile test interval. We believe that a four-fold increase in NO_x emissions can be more reasonably attributed to operational problems than to HiTEC 3000. Thus, we are left with only one HiTEC 3000 Explorer (No. 304), and we do not believe it is advisable to draw conclusions based on one vehicle. We also note that one of the non-HiTEC 3000 vehicles (No. 307) exhibits unusual behavior between 85,000 and 105,000 miles. A 35 percent decrease in NO_x emissions as the vehicle approaches the end of its "useful life" is difficult to accept as reasonable or expected vehicle performance.

As noted above, operational problems with one of the HiTEC Explorers (No. 306) cause us to question the representativeness of those data. The other HiTEC 3000 Explorer (No. 304) began the test program with NO_x emissions considerably higher than either of the two non-HiTEC 3000 Explorers. Over the duration of

the test program, Explorer No. 304 exhibits an increase in NO_x emissions from 0.176 to 0.221 gm/mile -- an increase of only 0.045 gm/mile over 100,000 miles. Conversely, one non-HiTEC 3000 Explorer (No. 305 shows an increase in NO_x emissions of 0.099 gm/mile (0.118 to 0.217) between 5,000 and 105,000 miles. The other non-HiTEC 3000 Explorer (No. 307) exhibits an NO_x increase from 0.113 to only 0.143 gm/mile at 105,000 miles. However, at 85,000 miles, the NO_x emission rate is 0.215 gm/mile -- an increase of 0.102 gm/mile between 5,000 and 85,000 miles.

SUMMARY COMMENTS REGARDING THE FORD DATA

- Ford's data for the two Escorts using HiTEC 3000 show an increase in HC emissions between 5,000 and 55,000 miles of never before seen proportion. How can any fuel additive at a concentration of 1/32 gram per gallon reasonably account for such an increase in emissions?

- After 55,000 miles, the Ford data for the two Escorts using HiTEC 3000 show no effect on differences in HC emissions. Why does the apparent HiTEC 3000 effect cease to exist after 55,000 miles?

- One of the non-HiTEC 3000 Explorers demonstrates incredibly low and constant HC emissions for the entire test program. We suspect that the emission performance of most other Explorers (and perhaps many other vehicles) would look poor when compared to Explorer No. 305. In fact, the other non-HiTEC 3000 Explorer has average HC emissions that are 88 percent greater (0.285 versus 0.152 gm/mile) than Explorer No. 305. Since neither Explorer No. 305 nor No. 307 used HiTEC 3000, what accounts for 88 percent greater HC emissions for Explorer No. 307?

- Based on measurements for one Explorer (No. 306), HiTEC 3000 does not effect HC emissions between 5,000 and 55,000 miles. The next measurement interval (105,000 miles) shows a huge increase in HC emissions; however, can an increase of this magnitude reasonably be attributed to a 1/32 gram per gallon fuel additive -- HiTEC 3000 or otherwise?

- One HiTEC 3000 Explorer (No. 304) exhibits a smaller increase in NO_x emissions with mileage accumulation than do either of the two non-HiTEC 3000 Explorers. Examining the data in this manner, do they not suggest that HiTEC 3000 has a beneficial effect on NO_x emissions?

Attachments

Figure 1. Ford's Data - Escorts
HC Emissions (gm/mile)

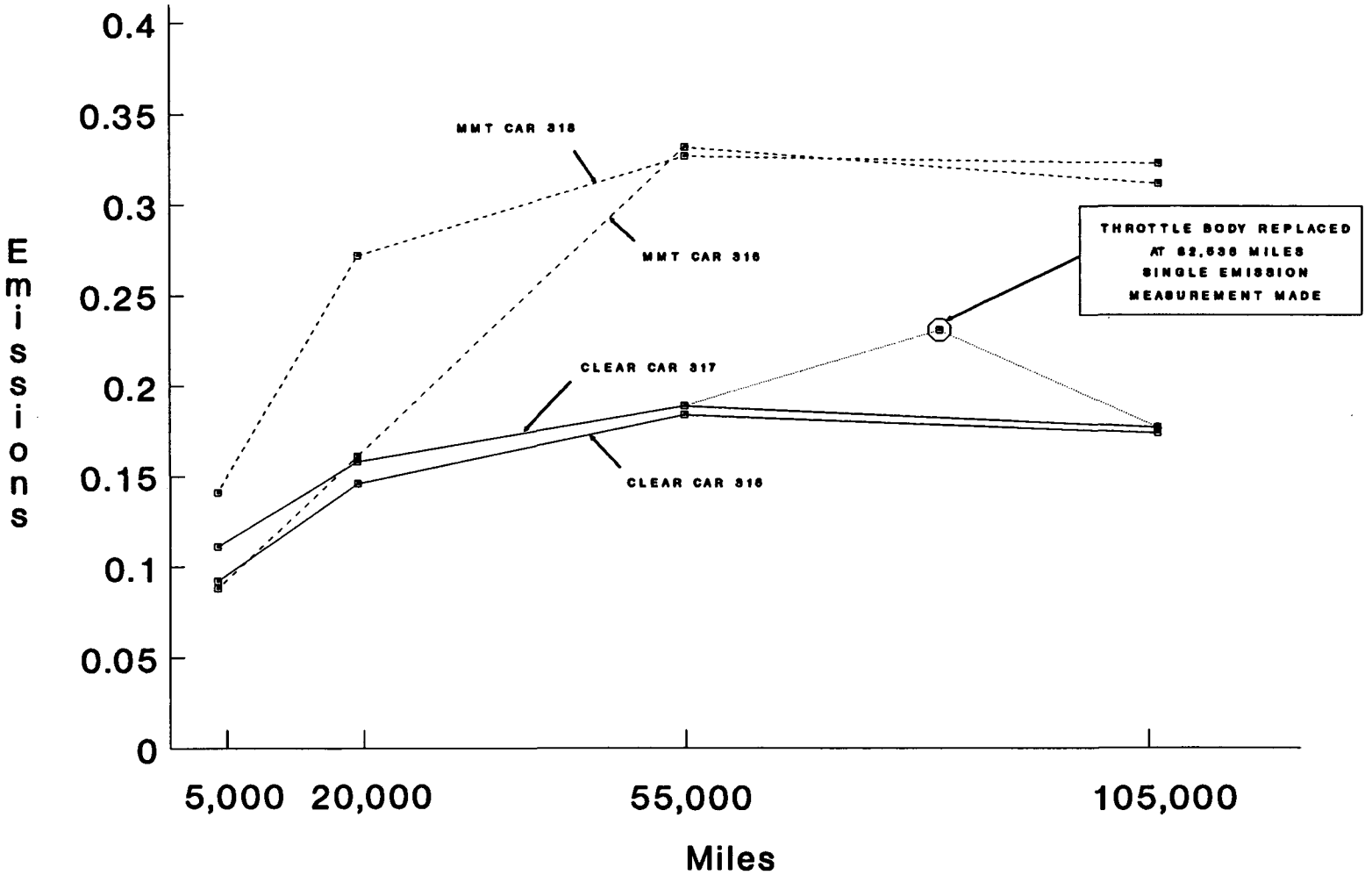


Figure 1A. Ford And Ethyl Data
HC Emissions (gm/mile) - Escorts

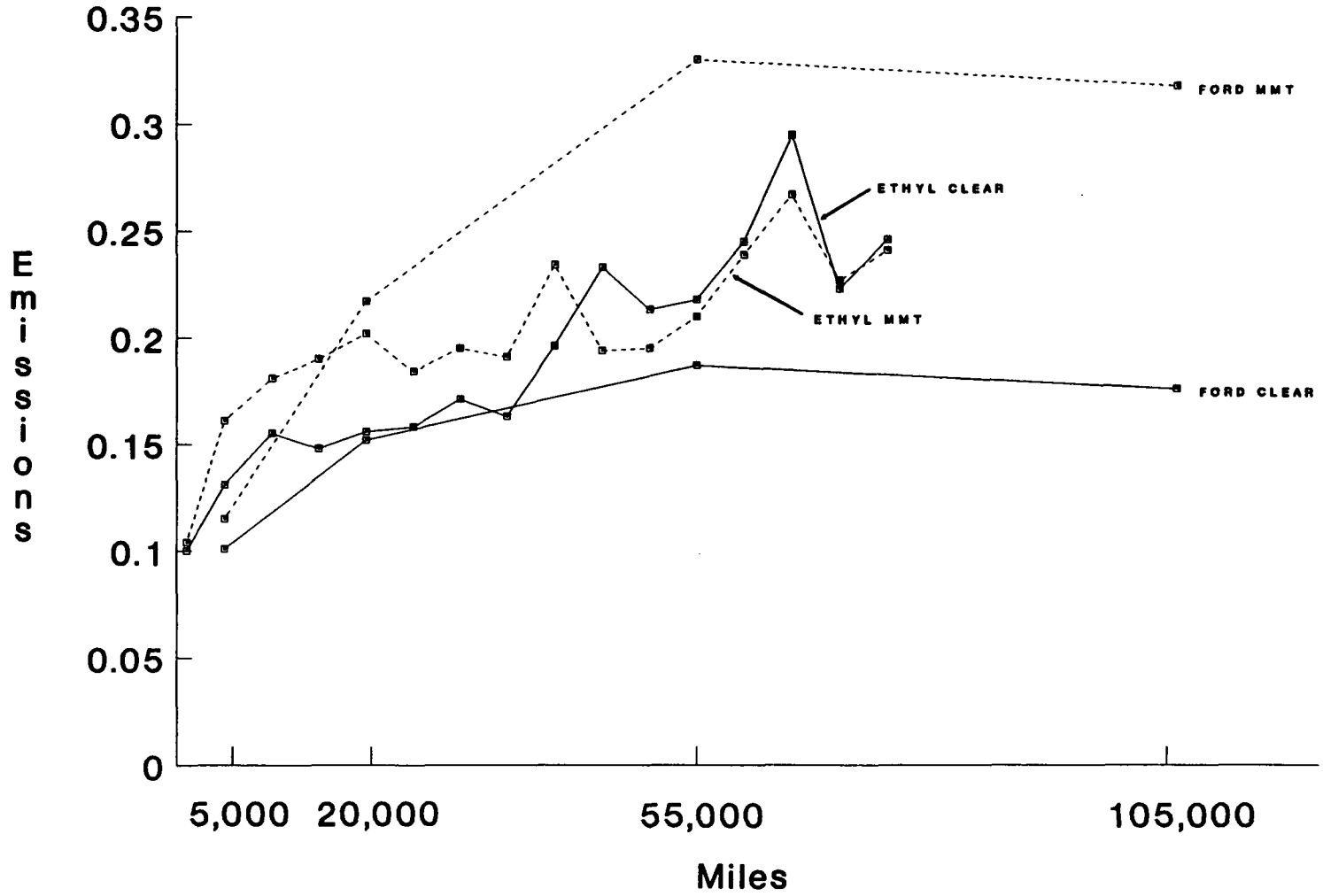


Figure 2. Ford's Data - Explorers
HC Emissions (gm/mile)

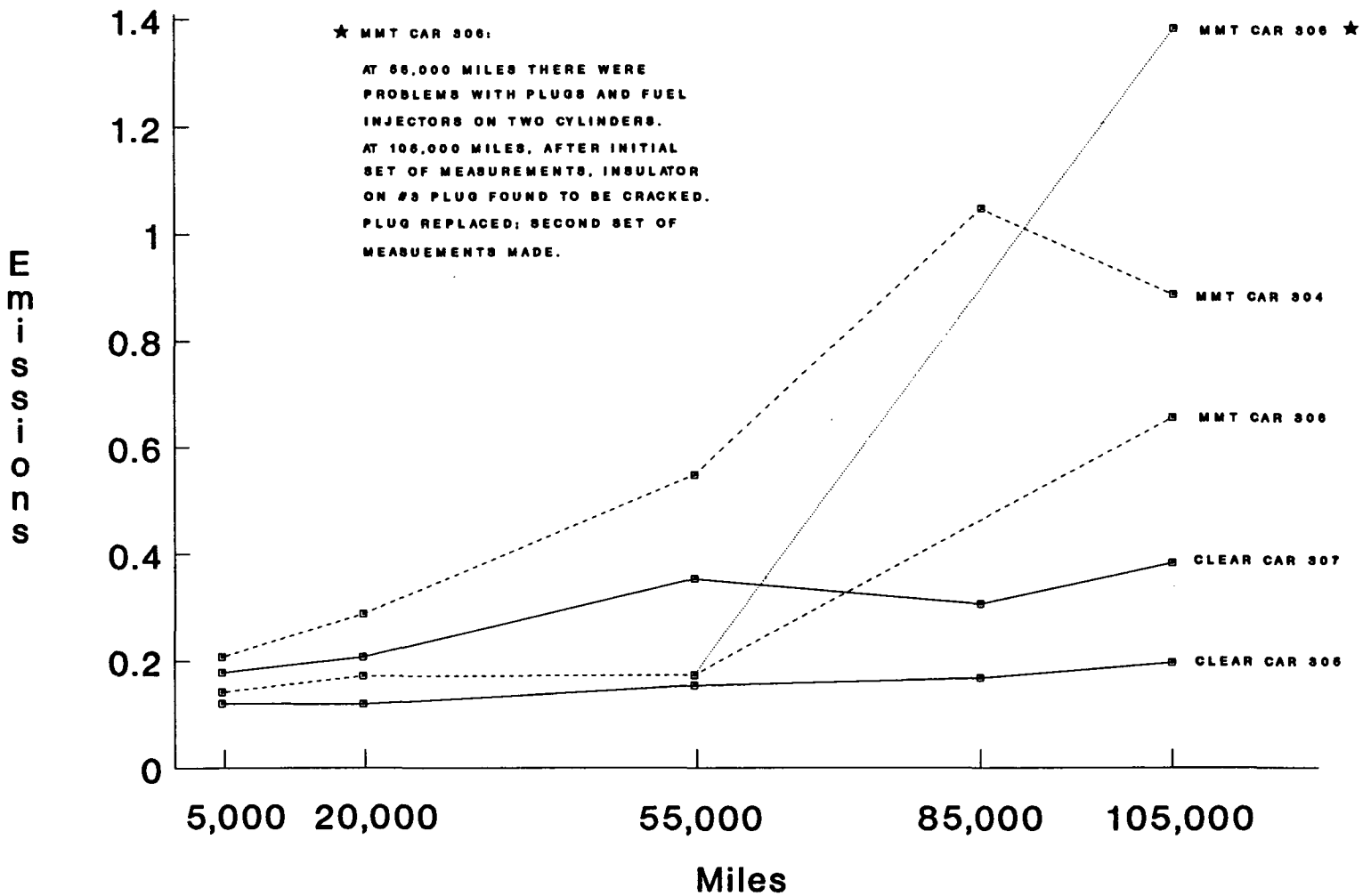


Figure 3. Ford's Data - Escorts
NOx Emissions (gm/mile)

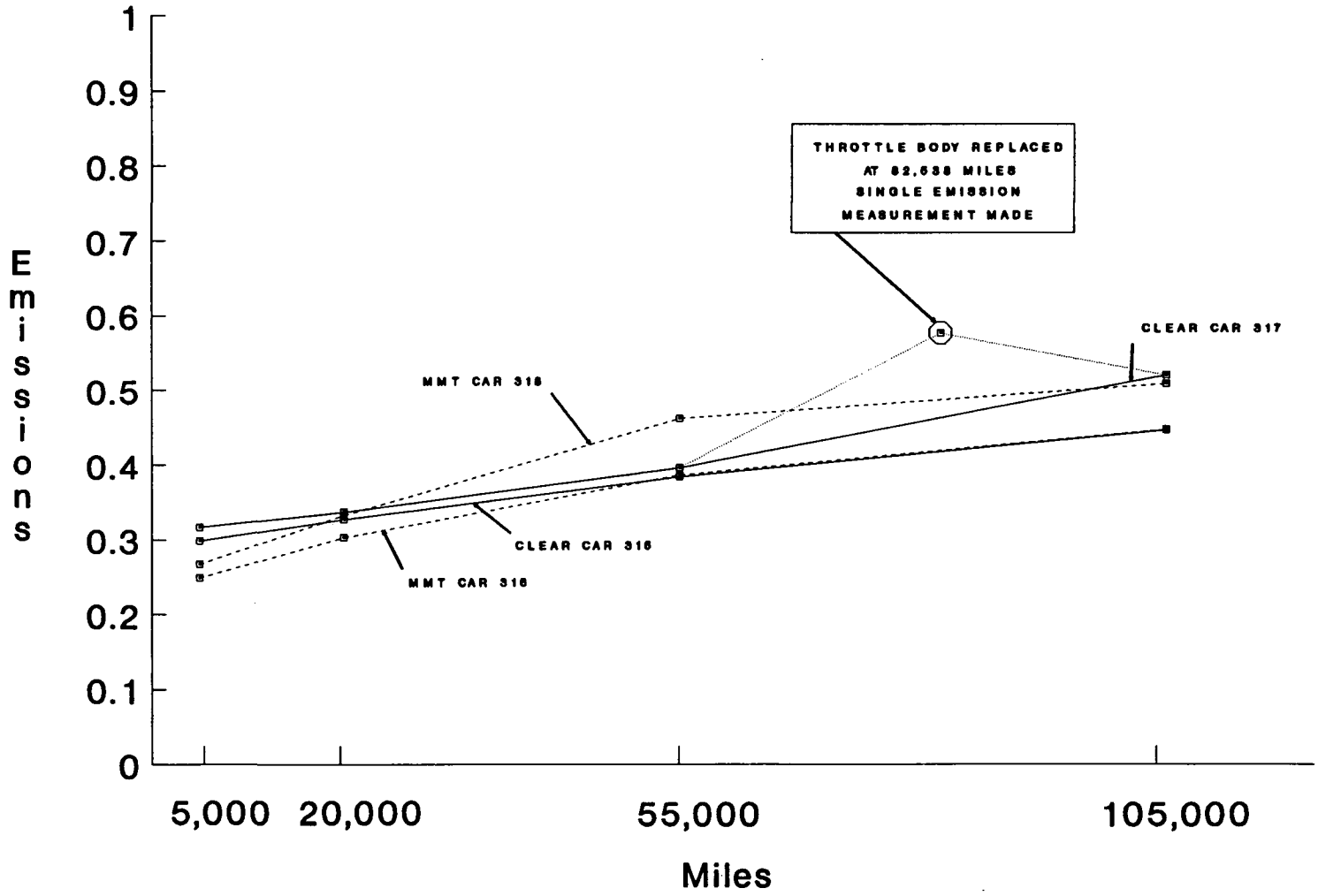


Figure 4. Ford's Data - Explorers
NOx Emissions (gm/mile)

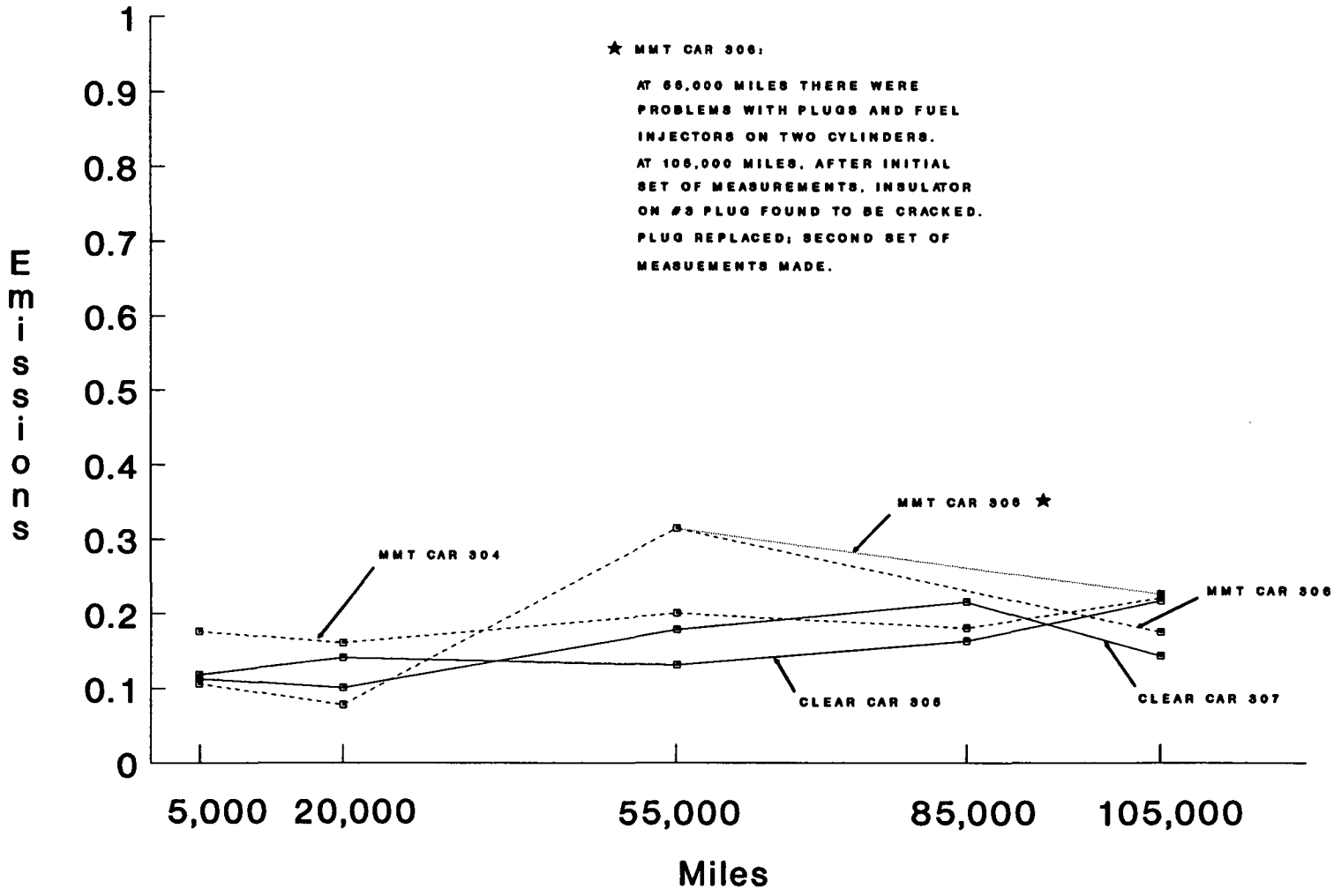


Figure 5. Ford's Data - Escorts
CO Emissions (gm/mile)

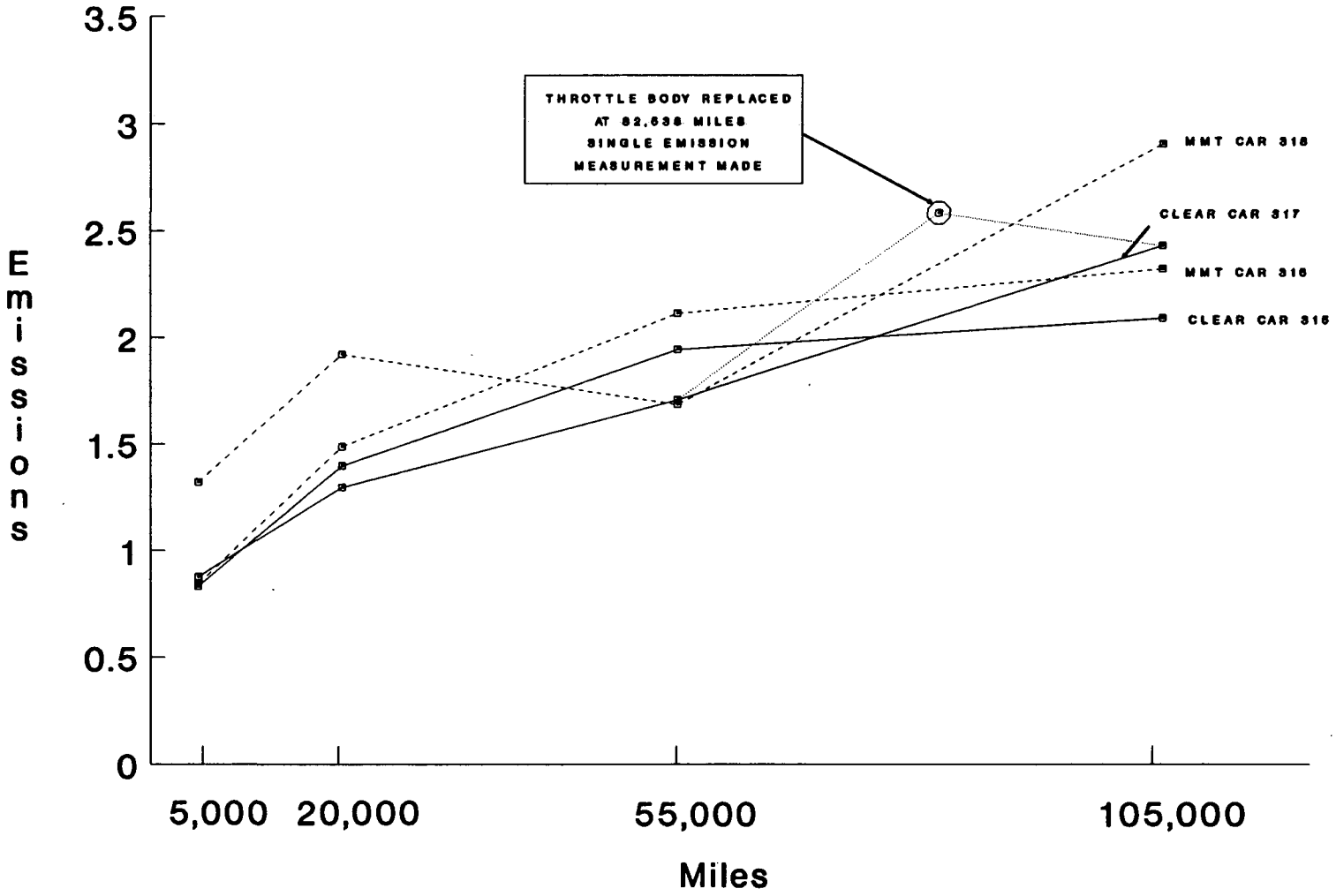
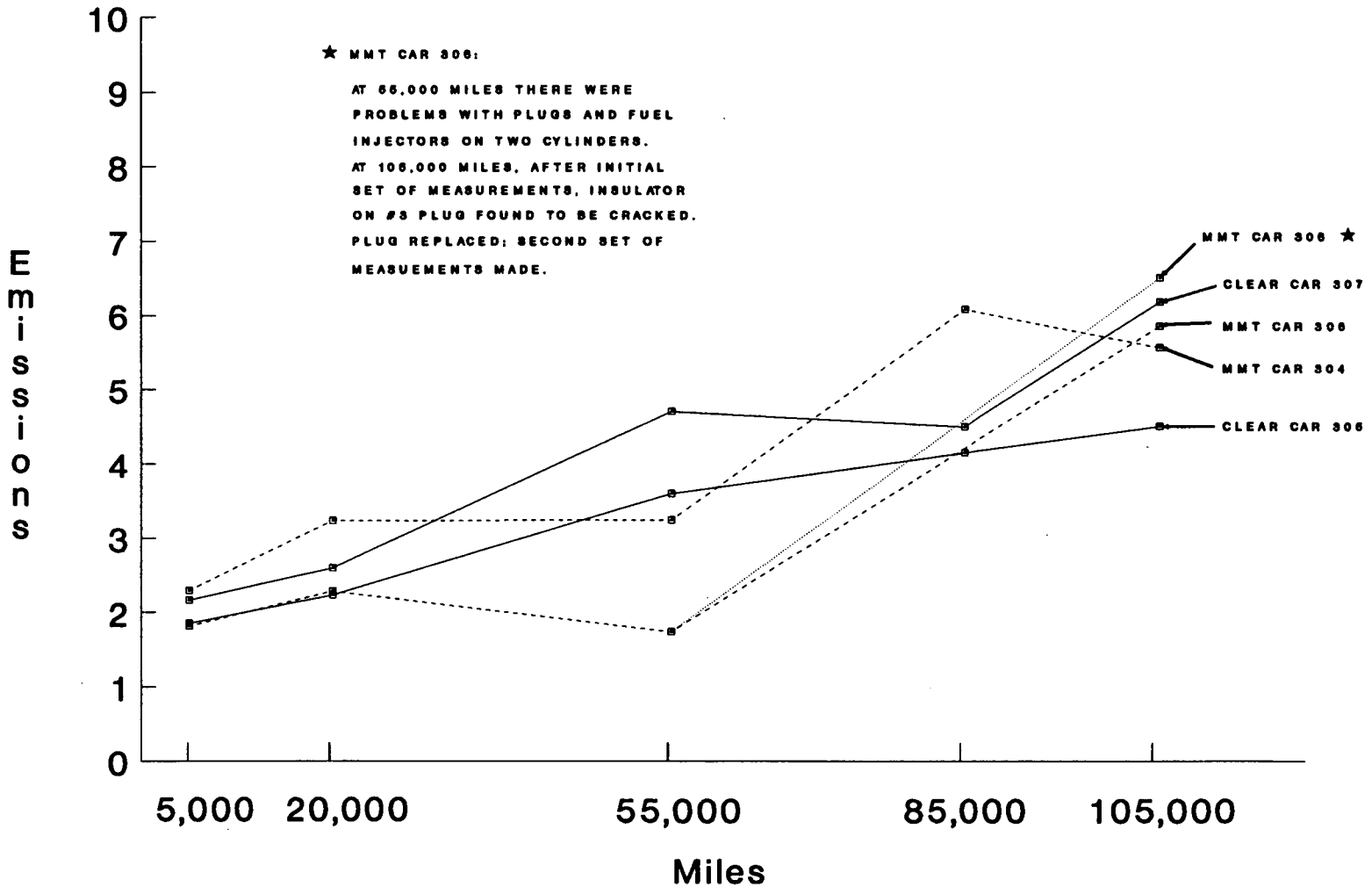


Figure 6. Ford's Data - Explorers
CO Emissions (gm/mile)



FUEL INJECTOR INSPECTION

Part of Ethyl's program on HiTEC 3000 is to evaluate components which might be affected by the use of a fuel additive. We measured catalyst performance on each car and found enhancement. Ethyl checked all oxygen sensors in actual vehicle emission tests and found no problems with this component. Additional bench test work has shown no degradation of catalysts using HiTEC 3000.

We also selected a set of injectors (multi-port) from one clear and one HiTEC 3000 car from vehicles in Ethyl's 48-car test fleet for flow evaluation. These flow checks were made at a flow bench at Southwest Research Institute ("SWRI") in San Antonio, Texas. SWRI measured the fuel flow of each injector and then compared the fuel flow to the flow from a new injector for that vehicle make. See Attachment 1.

Fouling was expressed as a percentage loss in fuel flow compared to new injector flow rate.

Fuel	Car No.	Engine Size	% Fouling
Clear	D1	3.0L V6	0.5
HiTEC	D4	3.0L V6	0.7
Clear	F6	5.0L V8	0.5
HiTEC	F2	5.0L V8	0.02
Clear	T6	3.0L V6	0.7
HiTEC	T5	3.0L V6	0.3
Clear	H5 (B 11)	2.8L V6	2.2
HiTEC	H6 (B 12)	2.8L V6	2.5
Clear	I (B 13)	3.8L V6	0.2
HiTEC	I (B 14)	3.8L V6	0.0

These data indicate that very little or no injector fouling had occurred in the 50,000 mile test of these units from either the clear or HiTEC 3000 test vehicles. Emission tests with new injectors also confirmed that fouling had not occurred. See In Re Application for a Fuel Additive Waiver Filed by Ethyl Corporation under § 211(f)(4) of the Clean Air Act (May 9, 1990), Appendix 2A ("Statistical Analysis of Automotive Exhaust Emissions in Support of Ethyl's HiTEC 3000 Fuel Waiver Application"), Attachment G. Finally, Systems Applications International conducted a statistical analysis of this data and concluded "there is no systematic difference between the fuel types with regard to degradation of injector flow." See Attachment 2.

SOUTHWEST RESEARCH INSTITUTE

6220 CULEBRA ROAD • POST OFFICE DRAWER 28510 • SAN ANTONIO, TEXAS, USA 78228-0510 • (512) 684-5111 • TELEX 244846

December 19, 1990

Mr. Denis L. Lenane
Ethyl Corp.
12257 Market St.
Livonia, Michigan 48150

Dear Denis:

As per your request we have measured the flow rate of 68 injectors. Four injectors designated B7-12, B-13-18, D, and F & T were new while the remaining 64 were used injectors. The flow-test data for all the injectors is included on the attached tables.

The injectors were apparently mislabeled as evidenced by the flow rate. The "D" series was supposed to have a flow rate of 65 ml. but the injectors designated D1 and D4 had flow rates of 72 ml. which corresponded to the "B13-18" series.

The "B13" and "B14" series had flow rates of 65 ml which corresponds to the "D" series--not the B-13-18 series flow rate of 72 ml.

The F and T series corresponded to the 47 ml flow rate found on the injector designated as F & T New.

You can visually check the injectors when you receive them to verify the designation numbers.

I will ship the injectors to your attention at the above address and ask our business office to send an invoice to Ethyl at the St. Louis address as per your P.O. # F-9012074419.

If you have any questions or require additional information please do not hesitate to contact me.

Sincerely,

Ronald M. Estefan

ATTACHMENT 1

Injector Number	Flow,ml	%Fouling	Avg.
B7 - 12 Series (New)	52	0	
B11- 1	50	3.8	
2	50	3.8	
3	52	0	
4	50	3.8	
5	52	0	
6	51	1.9	2.2%
B12- 1	50	3.8	
2	51	1.9	
3	50	3.8	
4	50	3.8	
5	52	0	
6	51	1.9	2.5
B13-18 Series (New)	72	0	
(D1)-1	72	0	
2	71	1.4	
3	72	0	
4	71	1.4	
5	72	0	
6	72	0	0.5
(D4)-1	71	1.4	
2	71	1.4	
3	71	1.4	
4	72	0	
5	72	0	
6	72	0	0.7
D Series New	65	0	
B-13-1	65	0	
2	65	0	
3	65	0	
4	65	0	
5	64	1.5	
6	65	0	0.2
B-14-1	65	0	
2	65	0	
3	65	0	
4	65	0	
5	65	0	
6	65	0	0

Injector Number		Flow, ml	% Fouling	Avg.
F & T Series New		47	0	
F2-	1	47	0	
	2	47	0	
	3	47	0	
	4	47	0	
	5	47	0	
	6	47	0	
	7	46	0.2	
	8	47	0	0.02
F6-	1	47	0	
	2	47	0	
	3	46	2.1	
	4	47	0	
	5	47	0	
	6	47	0	
	7	46	2.1	
	8	47	0	0.5
T5-	1	47	0	
	2	47	0	
	3	47	0	
	4	47	0	
	5	46	2.1	
	6	47	0	0.3
T6-	1	47	0	
	2	45	4.2	
	3	47	0	
	4	47	0	
	5	47	0	
	6	47	0	0.7

Systems Applications International

4600 Marriott Dr., Suite 420, Raleigh, NC 27612
919-782-1033 Facsimile 919-782-1716
A Division of Clement International Corporation
Environmental and Health Sciences

MEMORANDUM

To: Ben Fort

From: John Langstaff
Ralph Roberson

Date: January 18, 1991

Subject: Analysis of Ethyl injector flow data

Ethyl Corporation has conducted a series of tests to measure injector flows in automobiles using clear fuel and HiTEC fuel, in order to assess possible effects on injector flow due to the type of fuel. Tests were conducted on six or eight injectors from five automobiles for each fuel type; the resulting test data are presented in Table 1. Upon inspection of the average values for each automobile, it is apparent that there is no systematic difference between the fuel types with regard to degradation of injector flow (three cars exhibit higher flows and two cars exhibit lower flows with clear fuel).

This intuitively obvious conclusion is supported by a statistical analysis of these data. Statistical tests based on analysis of variance procedures were conducted which factor out the dependence of injector flow on automobile type and test for a remaining effect due to fuel type. The test results are attached for an analysis of variance with automobile and fuel type as main effects. Additional analyses show that there are no discernable automobile-fuel interaction effects, and a nested design (fuel type nested within automobile type) produces results similar to those attached. These tests demonstrate that no systematic differences between clear and HiTEC fuels can be detected from these data.

cc: Bill Brownell
Gary Ter Haar

Carolyn,
Copy for DRL, DLL, GDP
Ben
return orig. to me.

ATTACHMENT 2

TABLE 1. INJECTOR TEST DATA FROM ETHYL FLEET

Individual Injector Flows(ml)

Car ID	New	1	2	3	4	5	6	7	8	Avg
H-5 (Clear)	52	50	50	52	50	52	51	--	--	50.83
H-6 (HiTEC)	"	50	51	50	50	52	51	--	--	50.67
I-13 (Clear)	65	65	65	65	65	64	65	--	--	64.83
I-14 (HiTEC)	"	65	65	65	65	65	65	--	--	65.00
D-1 (Clear)	72	72	71	72	71	72	72	--	--	71.67
D-4 (HiTEC)	"	71	71	71	72	72	72	--	--	71.50
F-6 (Clear)	47	47	47	46	47	47	47	46	47	46.75
F-2 (HiTEC)	"	47	47	47	47	47	47	46	47	46.88
T-6 (Clear)	47	47	45	47	47	47	47	--	--	46.67
T-5 (HiTEC)	"	47	47	47	47	46	47	--	--	46.83

GLM analysis of variance - car, fuel main fixed effects model

General Linear Models Procedure

Dependent Variable: FLOW

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	204256.24479	34042.70747	99999.99	0.0
Error	58	18.75521	0.32337		
Uncorrected Total	64	204275.00000			

R-Square	C.V.	Root MSE	FLOW Mean
0.997151	1.023159	0.5686525	55.57812500

Source	DF	Type I SS	Mean Square	F Value	Pr > F
CAR	5	204256.22917	40851.24583	99999.99	0.0
FUEL	1	0.01563	0.01563	0.05	0.8268

Source	DF	Type III SS	Mean Square	F Value	Pr > F
CAR	4	6564.8385417	1641.2096354	5075.40	0.0001
FUEL	1	0.0156250	0.0156250	0.05	0.8268

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
CAR	1	50.76562500 B	283.79	0.0001	0.17888467
	2	64.93229167 B	362.98	0.0001	0.17888467
	3	71.59895833 B	400.25	0.0001	0.17888467
	4	46.82812500 B	294.62	0.0001	0.15894320
	5	46.76562500 B	261.43	0.0001	0.17888467
FUEL	1	-0.03125000 B	-0.22	0.8268	0.14216312
	2	0.00000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105
August 13, 1991

OFFICE OF
AIR AND RADIATION

Don P. Hollrah
Product Manager
Ethyl Petroleum Additives, Inc.
20 South 4th Street
St. Louis, MO 63102-1886

Dear Mr. Hollrah:

Enclosed is a summary of EPA and Ethyl Corporation correlation test results for EPA's "Red Dodge Dynasty" test vehicle. All tests at EPA were run according to the FTP, HFET, NYCC format we discussed with Denis Lenane at our June 11 meeting. Upon return of the vehicle from SWRI, mileage was accumulated with clear fuel and MMT treated fuel blended outside of a fuel conditioning cart. The tests run at EPA on July 25 and July 27 were purposely run with fuel blended in a fuel conditioning cart suspected of leaking Freon refrigerant. A gasoline sample was withdrawn at the time of vehicle refueling and analyzed for Freon; the Freon concentration is shown in the data table. All other return testing of the vehicle at EPA was performed with clear fuel or fuel blended with MMT outside of a fuel conditioning cart.

Please phone me at (313) 668-4216 if I can provide further information or assistance.

Sincerely yours,

Tom Schrodt

Tom Schrodt, Mechanical Engineer
Correlation and Engineering Services
U.S. EPA Motor Vehicle Emission Laboratory
2565 Plymouth Road
Ann Arbor, MI 48105

Enclosure

cc: D. Rortum

ENGINEERING OPERATIONS DIVISION
EPA / ETHYL CORRELATION TEST PROGRAM

VEHICLE: 1991 Dodge Dynasty 3.3L
VIN: 1B3XC46R5MD204599
IW: 3375 Pounds HP: 6.9 HP

FUEL: SUN Certification Test Fuel

FTP TESTS

Date	Odometer	Lab	Fuel	THC GPM	CO GPM	NOx GPM	F.E. MPG	Part. GPM	Freon Conc
6/13/91	8638	EPA	MMT/FREON	0.381	3.494	0.573	21.8	0.032	Unknown
6/14/91	8720	EPA	MMT/FREON	0.345	2.367	0.526	21.7	0.016	Unknown
6/18/91	9232	EPA	MMT/FREON	0.449	3.816	0.635	22.2	0.068	Unknown
6/19/91	9358	EPA	MMT/FREON	0.441	3.325	0.691	21.9	0.067	Unknown
EPA MMT/FREON		Mean		0.404	3.250	0.606	21.9	0.046	
		Standard Deviation		0.050	0.568	0.072	0.2	0.026	
7/1/91	9438	SwRI	MMT/FREON	0.44	3.09	0.64	21.0	0.044	Unknown
7/2/91	9449	SwRI	MMT/FREON	0.49	3.07	0.58	21.0	0.042	Unknown
SwRI MMT/FREON		Mean		0.47	3.08	0.61	21.0	0.043	
		Standard Deviation		0.04	0.01	0.04	0.0	0.001	
7/3/91	9474	SwRI	MMT	0.41	2.92	0.52	20.8	0.015	None
7/8/91	9557	SwRI	MMT	0.40	2.95	0.48	21.0	0.006	None
7/9/91	9632	SwRI	MMT	0.38	2.80	0.45	21.2	0.002	None
SwRI MMT		Mean		0.40	2.89	0.48	21.0	0.008	
		Standard Deviation		0.02	0.08	0.04	0.2	0.007	
7/10/91	9720	SwRI	Clear	0.39	2.82	0.47	21.4	0.003	None
7/11/91	9794	SwRI	Clear	0.41	2.90	0.45	21.5	0.003	None
SwRI Clear		Mean		0.40	2.86	0.46	21.5	0.003	
		Standard Deviation		0.01	0.06	0.01	0.1	0.000	